The Engineer

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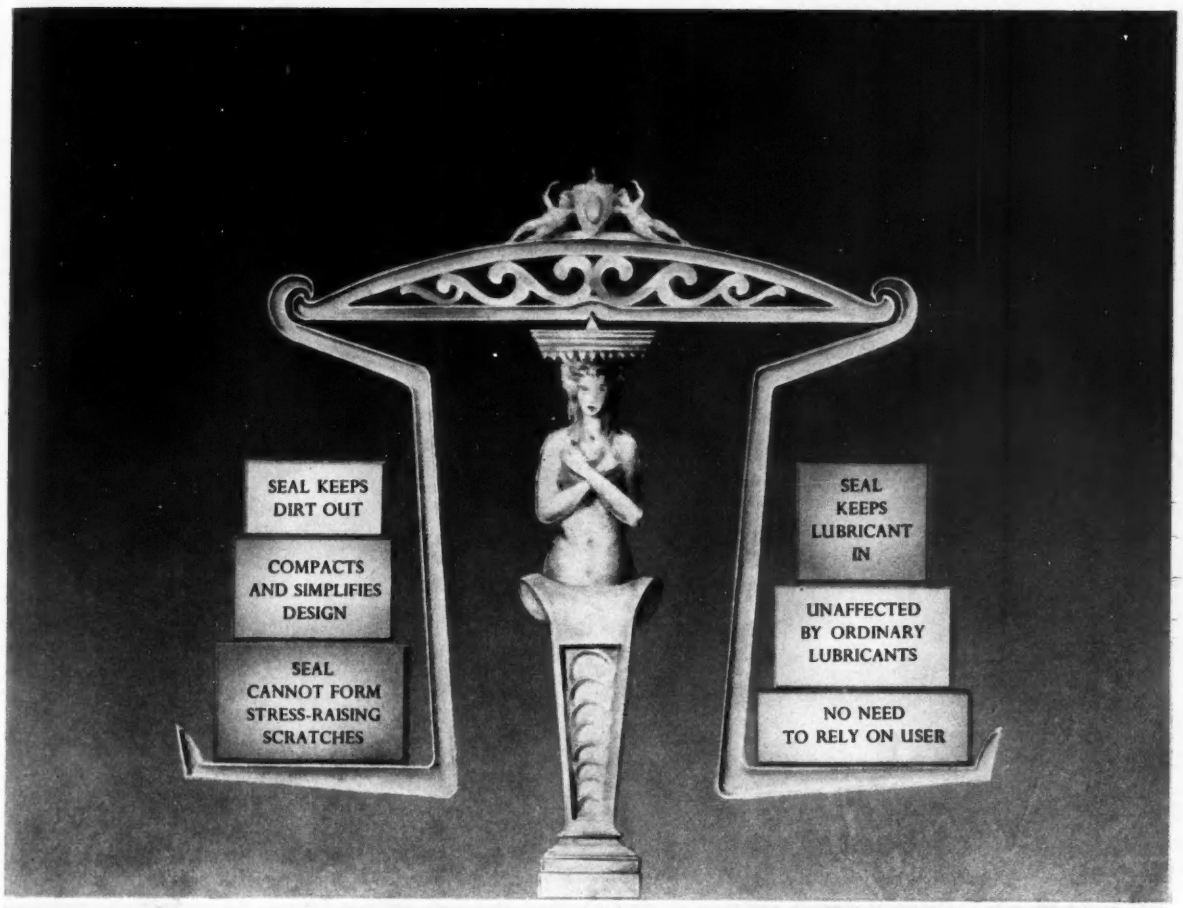
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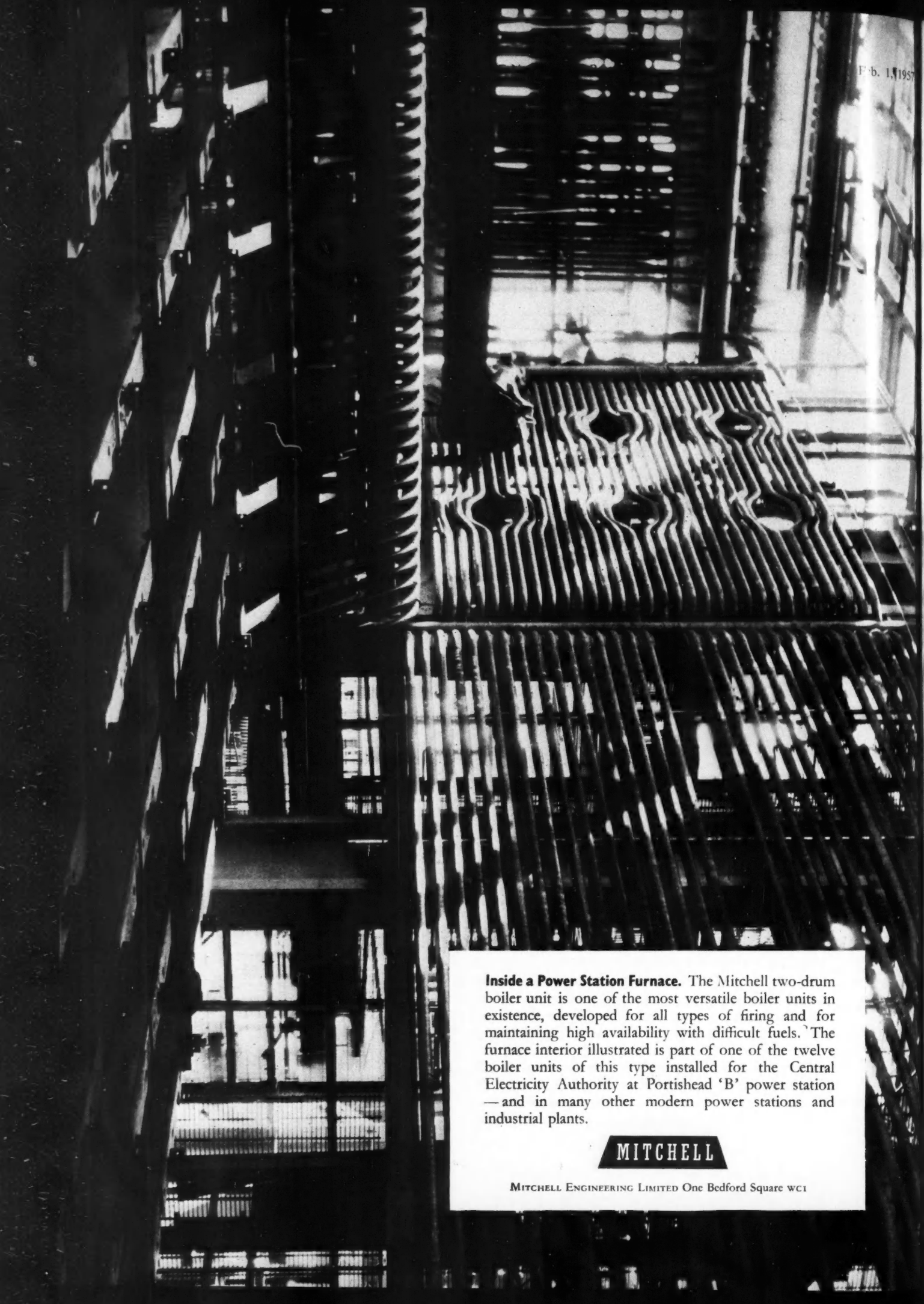

Inside a Power Station Furnace. The Mitchell two-drum boiler unit is one of the most versatile boiler units in existence, developed for all types of firing and for maintaining high availability with difficult fuels. The furnace interior illustrated is part of one of the twelve boiler units of this type installed for the Central Electricity Authority at Portishead 'B' power station — and in many other modern power stations and industrial plants.

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THE ENGINEER

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TRANSATLANTIC TELEPHONE CABLE

A casual visitor to the Institution of Electrical Engineers in London on the evening of Thursday, January 24, might have supposed that the occasion was, just as described on the I.E.E. programme, an "Ordinary Meeting." There was, indeed, an exceptionally large attendance and half an hour before the meeting began all the unreserved seats in the lecture theatre were occupied, justifying the provision that had been made for an overflow meeting in an adjoining room. But, initially at least, there was nothing unusual about the proceedings, which opened at 6.45 p.m. with the accustomed decorum appropriate to routine business and the introduction of new corporate members. It was not until 7 o'clock G.M.T. that this "Ordinary Meeting" became recognisably a special occasion. Then, for three-quarters of an hour, the assembly at Savoy Place was linked by the transatlantic telephone cable with The American Institute of Electrical Engineers in New York and The Engineering Institute of Canada in Montreal. For the first time these three sister institutions were able to take part in a joint meeting across the North Atlantic and it was appropriate that the subject for discussion should be the planning, design and laying of the submarine telephone cable which made that simultaneous meeting possible.

It was specially appropriate that the symposium of papers, in which the details of the transatlantic cable were elaborated, should be presented jointly, for the scheme for the cable link was essentially a joint venture. It was a major engineering enterprise, costing about £15,000,000, and it stands as a unique example of collaboration between its main sponsors—the American Telephone and Telegraph Company, the British Post Office, and the Canadian Overseas Telecommunication Corporation—and the American, British and Canadian firms who shared in the manufacture of the cable and accessories. The complexities of such a combined operation were increased by the differences that existed between American, British and Canadian practice and experience of submarine cables, repeaters and other accessories. It was, perhaps, easy to establish the principle that the allocation of individual tasks should be by merit, so that each partner contributed the service for which it was best equipped. It must have been much less easy to apply these principles to each component of the link, as may well be imagined. Some of the decisions were discussed in the recent symposium. For example, the American design of flexible one-way repeater as used for the Key West–Havana cable was adopted for the deep-sea part of the transatlantic cable, between Newfoundland and Oban, because of its "proven integrity" for such service. For the comparatively shallow crossing between Newfoundland and Nova Scotia, however, it was feasible to use the G.P.O. "rigid" repeaters which were designed for two-way amplification so that a single cable would provide "go" and "return" channels for sixty circuits.

As was pointed out in the foreword to the recent symposium, the completion of the first transatlantic telephone cable was particularly opportune because further growth in traffic on the radio circuits between London and New York was limited by the fact that most of the available frequency spectrum was already occupied. There has, in fact, been a substantial increase in traffic since the transatlantic cable went into operation. So much so, that, as Sir Gordon Radley foresaw in his I.E.E. presidential address last October, the laying of a second telephone cable across the North Atlantic may soon be justified. The demand, indeed, is likely to come soon enough to require urgent consideration of a cable having "the greatest capacity technically possible." Sir Gordon believes that eighty circuits in a single cable or 200 in a two-cable system would be objectives only just beyond present limits of repeater spacing and cable diameter, and that, with present tariffs, such cable links should prove commercially sound. It will come as no surprise to learn that the British Post Office and its American collaborators are continuing with intensive programmes of research and development on submarine cable systems and that further technical progress can be anticipated, to meet future requirements for "continuous, reliable and high quality services."

SLIGHTLY OILED

In our last issue, Dr. Lewicki, concluding his article upon the hydrodynamic lubrication of piston rings and similar parallel slides, observed that engineers had for long attempted to rely upon a "classical" theory of lubrication, despite abundant evidence that an inclined surface was not necessary to sustain a load. That very day, such evidence was augmented when two papers upon the behaviour of piston rings in lubricated

cylinders were discussed by the Institution of Mechanical Engineers. The keynote of both papers was that the rings, on each stroke of the piston, were separated from the cylinder wall by a film of oil of a by-no-means-negligible thickness—Professor Saunders quoted figures above and below four-tenths of a thousandth of an inch. Professor Saunders had measured the instantaneous friction force on a piston in a reciprocating cylinder. Breakdown of the oil film, he found, occurred only when the piston was within 7 deg. each side of t.d.c. and then only provided the oil temperature was allowed to rise, and when, additionally, the pressure above the piston (and presumably behind the ring) was high. This work does not, as the authors point out, establish that an oil flow in a parallel gap can support a load : for the ring had been run in with a reciprocating motion, and the resulting near-parabolic profile, with a depth of perhaps 0·0001in, could, it was shown, explain the observed friction in accordance with Reynolds' original findings. The logical inference was drawn that new rings should be finished with such a profile, so that boundary lubrication should not obtain during running in. The point was made in discussion that the inconsistency of the results obtained in practice with the square section ring could be attributed to its extreme sensitivity to minute distortions or wear. It may well be that the success of those rings assembled from steel strip instead of cast in iron is due to their being able to shape themselves against the cylinder wall.

The fact that rings, even " scraper " rings, leave oil on the bore will not come as a surprise to those engineers who have attempted to gain control of oil consumption. Dr. P. de K. Dykes demonstrated the nature of the problem confronting them with one significant experiment. Above a combination of rings giving a good (low) oil consumption, he added another past which oil could not pass downwards—and the result was a consumption of fearful volume. But some indication of the difficulty facing the development engineer can be drawn from the realisation that this change represented the removal of a uniform layer of oil one hundredth of a thousandth of an inch in thickness on each upstroke. To emphasise how fundamental is this concept that relatively large quantities of oil pass the ring in each direction, and that the loss is the small difference, Dr. Dykes remarked that nine months' testing elapsed before it was realised that, if there was to be any oil loss in his apparatus, it was essential to catch the oil thrown into the " combustion chamber " before it could return to the cylinder wall. Thus, if this work is to have application to real engines, we face the conclusion that the only oil consumed is that which is removed from the wall and thrown clear of the piston. That this is tenable was the theme of one contributor to the discussion, who examined the heat transfer through a thin film on a cooled wall and concluded that the oil would not be oxidised. This accepted, Dr. Dykes has much more of interest to say. Given a " down-passing " ring assembly, a good oil consumption may depend on the piston not being able to touch the bore above the rings and scatter the oil. It was observed in the laboratory that a distinct trail of oil was left on a cylinder wall by a 0·005in ring gap, and if the piston touched this trail there was virtually a gusher. This, of course, immediately reminds us that racing engines have been built in which the piston was supported entirely by the rings and did not touch the cylinder : and that this arrangement may be attractive still was emphasised by the discussion of the influence of the inertia of the oil trapped behind the ring, though the relevant results were contradictory.

It is the questions, rather than the answers, about piston rings that we can now perceive. Dr. F. T. Barwell and Mr. M. J. Neale will wish to correlate the findings and theories of loaded parallel sliders. The engine designers will view askance the need to keep cool oil on the cylinder walls when it is becoming increasingly clear that wear is principally attributable to corrosion, and therefore the metal temperatures should be over 80 deg. Cent. The piston ring manufacturers, contemplating the infinite variety of productions they have evolved by empirical approaches, will hardly be encouraged to hear it urged against the taper ring that it might be inserted upside down. (Dr. Dykes made the worthwhile point that any chamfer visible to the naked eye was, in effect, square.) But one thing is clear. We shall not again hear the plaintive exculpation of the oil-consuming engine—" oil is cheaper than cast iron."

" DAMTHEISM "

There is, it seems, a new religion in the world. Not here, of course, but in the East, in India. In a recent issue of *The Listener* there is a little piece by a B.B.C. correspondent about India's water conservation schemes, and in particular the opening of Hirakud dam. " The so-called multiple-purpose projects have become places of national pilgrimage," he writes ; " Mr. Nehru calls them ' the temples where I come to worship ' and no V.I.P. from abroad can escape being shown at least one." So far so good. It seems quite a serviceable religion, and at least illustrative of that great principle that the more benevolent gods are amongst the finest works of man. But at this point the correspondent rather runs amok. "There is a complete jargon for them" he says, " full of things called ' Qsecs ' and ' acre-feet,' ' pinstocks,' and ' rip-rap,' and a process called ' grouting.' " So all the skill, all the science and experience of the designers of these schemes, he reduces to " a complete jargon," and that rather unevenly spelt !

It is too much to expect that Mr. Nehru's enthusiasm will spread to this country. We can only express a twinge of envy that, over here, such wide recognition is not likely to be given to engineers. Hirakud, as far as we can judge, was not a dam of exceptional difficulty to build. No more difficult, we expect, than, for instance, the Daer dam, recently completed in Lanarkshire, but a larger structure, six times as long, but not very much higher. And because of the enormous catchment it controls on the Mahanadi River, it will form a reservoir of about 4½ million acre-feet, as against only about 20,000 for the Scottish dam. That makes the Scottish dam potentially a more expensive job than the Indian one, and illustrates the main point, that water is becoming a critical commodity in Britain. The enormous flood plains of India attract attention immediately, but the importance of industrial and domestic water supplies in the green, rainy valleys of this country may be overlooked. It is just as important for the Lanarkshire man to have a drop of water to put in his Scotch as it is for the Indian to be able to irrigate his rabi fields. One must also remember that that " reactionary " organisation of the British Raj, the Public Works Department, achieved a great deal in all aspects of this class of work, except possibly, publicity.

But under normal conditions in this country only a small minority of people take much notice of dams. There are those whose business it is to build dams and who presumably approve of their building ; and there are those who regard any interference by man with Nature as desecration and who are therefore against dams. Damtheism, in fact, is not likely to flourish here. Indeed, the only time we can recall any general enthusiasm about dams in this country was when the R.A.F. destroyed the Mohne and Eder dams in Germany. That event produced, eventually, an appreciative ditty called " The Dam Busters March." The usual procedure at present, when a new dam is inaugurated, is to publish a little booklet, embellished by a gallery of photographs of eminent mayors, councillors, conveners, and so on, all resplendent in robes and chains of office. Then perhaps a life history of some public personage, who came along for the opening ceremony ; a brief description of the dam; and, finally on the back page in small type, a list of the engineering firms who designed and built it. Obviously the booklet should be turned back to front, by any right-thinking proselyte of damtheism !

A Seven Day Journal

Electrical Engineering Training

A REPORT dealing with the training of graduates for professional electrical engineering has been published by the Institution of Electrical Engineers. Members of the joint committee which prepared the report were appointed by the council of the Institution in consultation with the council of the British Electrical and Allied Manufacturers' Association, the Radio Industry Council and other interested bodies. Recommendations made in an earlier report on the practical training of professional electrical engineers have been brought up to date, and the new report recommends that all students who have followed a full-time course of education in engineering or science and who wish to qualify as chartered electrical engineers should complete a two-year programme of training. This training programme has been broken down into three periods. The first, basic workshop training, takes three to four months ; the second, general mechanical and electrical engineering training, takes from eight to fifteen months. The final period, during which the training programme should become progressively more specialised and which should be planned according to the trainee's chosen functional activity, requires six to twelve months. Each of these phases of training is fully discussed in the report and the objects of each are supplemented by representative schemes for a number of branches of the industry. The report goes on to discuss training programmes for operating concerns and refers to the training in research establishments of graduates wishing to qualify as chartered electrical engineers. The need for training programmes to be carefully planned and supervised and for the trainee to appreciate the importance of human relations in industry is stressed throughout the report. Copies of the report, price 2s., may be obtained from the Institution, Savoy Place, London, W.C.2.

Commercial Agreement for Pressurised-Water Power Plants

A COMMERCIAL agreement relating to small atomic power plants has been made between Alco Products, Inc., New York, and Humphreys and Glasgow, Ltd., London. Under this agreement, the British company has exclusive selling rights, outside the North American continent, of small nuclear power plants made to the designs of Alco Products, Inc. Some details of the scheme were announced at a press conference in London earlier this week. The British company is stated to be in a position to accept orders for small nuclear power plants, with completion times about the same as for comparable conventional plants. The installations would incorporate pressurised-water reactors similar in principle to that in the U.S. submarine " Nautilus " and to the Army Package Power Reactor (APPR-1) which is nearing completion by Alco at Fort Belvoir, Washington. Similar Alco plants of three sizes, giving net electrical outputs of 2MW, 5MW and 10MW, are stated to be available, with designs in hand for 25MW. It is estimated that a 10MW plant using enriched uranium would cost about £2,000,000, would have a core life before refuelling (at 80 per cent load factor) of thirty months and would generate electricity at a cost of about 1½d. to 2d. per unit. Initially about two-thirds of the equipment for such a plant would be made in Great Britain and the remainder, including the fuel elements and probably the control mechanism, would come from the United States. Ultimately, however, it is probable that all the manufacturing for markets outside North America would be done in Great Britain.

Institution of Civil Engineers

ON Tuesday of last week, the Institution of Civil Engineers held a special general meeting to elect a president for the remainder of the year, following the death of Mr. H. J. F. Gourley on December 18. In accordance with the by-laws, the council submitted the name of the senior vice-president, Sir Arthur Whitaker, M.I.C.E., who was unanimously elected to the office of president. Sir Arthur, who is now a partner in the consulting firm of Livesey and Henderson, was for many years Civil Engineer-in-Chief at the Admiralty. He was born in 1893, and was educated at Liverpool Institute High School and Liverpool University. Sir Arthur joined the Civil Engineer-in-Chief's department of the Admiralty, at Rosyth, in 1915. Subsequently, he served in Jamaica, Malta, Portsmouth and Singapore, and became Deputy Civil Engineer-in-Chief in 1934. He was appointed Civil Engineer-in-Chief in January, 1940, and retired in 1954. During his service at the Admiralty, Sir Arthur was responsible for all civil engineering works connected with dockyards and naval bases at home and abroad, for the construction of Royal Navy air bases and armament depots, and for the preparations concerned with invasion of Europe in the second world war. One of his special wartime achievements—which has subsequently been particularly useful in peace time—was the construction of the Scapa Flow causeways. Sir Arthur was created K.C.B. in 1945, and a Commander, Legion of Honour, in 1947. He was elected a vice-president of the Institution of Civil Engineers in 1953.

The Engineer
100 Years Ago

(JANUARY 30, 1857)

" APPLICATION OF MACHINERY IN THE WAR DEPARTMENT "

" During the last few years important improvements have been made in the manufactories of the War Department. Up to a recent period by far the greater proportion of the work, in making the munitions of war, was performed by hand labour. In 1842 there were but two steam-engines, together equal to 32 horse-power, which gave motion to a few machines for sawing and planing the timber of gun-carriages. The simple statement that there are now 68 steam-engines, with a nominal power equal to 1,170 horses, giving motion to 16,540 feet of shafting, 18 steam hammers, 64 hydraulic presses, and 2,773 machines of various description, will afford some notion of the extraordinary effort which has been made to render the several establishments thoroughly efficient and fitted for any emergency. These improvements embrace a variety of detail.

" Without prejudice, the United States of America, the continent of Europe, and our own country, have been searched for the most superior appliances, and hundreds of machines have been designed for purposes peculiar to the War Department, but which may be usefully employed in the general manufactures of the kingdom. From these important changes and improvements the greater proportion of war stores can now be produced with unskilled labour. From the completeness of the machinery, and the general arrangement of the plant, the cost of production of the several articles is reduced to a minimum, and there being no pecuniary interest calculated to induce an inordinate desire for saving, either in regard to the quality of the materials employed, or in the amount of workmanship necessary to be expended, there is great security afforded that the several articles are the very best for the purpose which can be made, a very most vital consideration in regard to war stores and material, on which may some day depend the fate of battles and the nation's honour."

Aircraft Development and Research

ON Friday last, the Minister of Supply, Mr. Aubrey Jones, opened a test house for fuel flowmeters at the Rochester works of Elliott Brothers (London), Ltd. He took the opportunity to observe that at present the scale upon which the Services were equipped was reducing, and it was at a time of contraction that there was most difficulty in allocating the efforts that were made. The Minister of Supply had the position of an intermediary between the armed forces and industry, and he could say that what both parties needed was to shorten the lead time for new ideas to be used. In this respect Great Britain was lagging and improvement must come : he foresaw the need for control engineering—" automation "—to be applied to the development process. The work of instrument makers was vital to success in this activity. At present, the Ministry was spending roughly equal funds on development and on production contracts, and he felt that " automation " of development was not being applied fast enough. The widespread view was that the prevailing high taxation was the cause of this, which might well be the case : he pointed out, however, that while conservatism was desirable in politics it was a handicap in research and development work.

Canadian Water Power

TRENDS towards increased consumption of electrical power are world-wide, and are well illustrated by figures for new hydro-electric plant commissioned in Canada during 1956. The figures are given in a review prepared by the Canadian Minister of Northern Affairs and National Resources. New hydro-electric capacity totalling 845,000 h.p. (about 630MW) was added during the year, to make a total water power installation of nearly 18,500,000 h.p., which is estimated to be 28 per cent of the country's total resources. The rate of commissioning is increasing, and it is estimated that 1,500,000 h.p. will be added in 1957, and 2,500,000 h.p. in 1958. The province of Quebec has the largest water power installation and during 1956, 450,000 h.p. was brought into use at one site in Quebec—the Bersimis No. 1 development of the Quebec Hydro-Electric Commission. Of the total of 845,000 h.p. of new plant, 514,300 h.p. was commissioned in Quebec, and 243,500 h.p. in British Columbia. Most of the large-scale schemes under construction or investigation in Canada are already known to readers of this journal. Hydro-electric power resources are still meeting most of the demand, but in Ontario particularly, it is expected that considerable increases will be needed in thermal capacity in the next few years, as well as the hydro-electric expansion. One possibility in the future is apparent from the 1956 survey. During the year the British Newfoundland Corporation completed investigations on the Hamilton River in Labrador, which, it is stated, proved that development of the Grand Falls, one of the larger sources of untapped water power in the world, is feasible.

Salvaging of the "Empress of Canada"

By CAPTAIN W. R. COLBECK, R.N.R.*

No. II—(*Concluded from page* 131, *January* 25)

Here reprinted are abstracts from the twenty-ninth Thomas Lowe Gray Lecture presented before the Institution of Mechanical Engineers on Friday, January 18. *In January*, 1953, *the "Empress of Canada," a passenger liner of* 20,021 *gross tons, sank on her side in Gladstone Dock, Liverpool, as a result of a fire. The events leading to the loss and the operations of uprighting and refloating are described with details of methods and materials used and the difficulties encountered.*

Buoyancy Pontoons.—Eleven Admiralty salvage pontoons (A.S.P.s) were secured at the port side of the deck close to the dock bottom, providing an upward buoyancy force of 880 tons. These pontoons are cylindrical in shape, each 33ft long by 13ft diameter, subdivided by internal bulkheads and fitted with connections for blowing and venting. When fully submerged and blown they have a buoyancy of 80 tons each. They are fitted with a tube passing through the diameter about 8ft 6in from each end to take the securing wires or chains. Five pontoons, two forward and three aft, were secured by wires passing right round the hull from the port deck edge round the bottom and up to the starboard side.

With the six pontoons in way of the boat deck it was not possible to pass the securing wires right round the hull, and they were secured by the bight of each wire being led through a heavy shackle in a 6in wire strop round the base of a Welin boat davit on the port side, the wire then leading up the face of the deck to the starboard side. The wires were 7in in circumference, 6×61 construction, with a breaking strain of 161·2 tons, the 6in wire strop being of 6×37 construction, with a breaking strain of 130·3 tons.

Each pontoon was held by two 7in wires, the end being secured to the pontoon by a toggle bar through the eye in the wire resting across the mouth of the chain pipe, passing down through the pipe and thence under the wreck or through the 6in strop and made fast with a carpenters' stopper bearing against a specially constructed tabernacle welded to the shell plating.

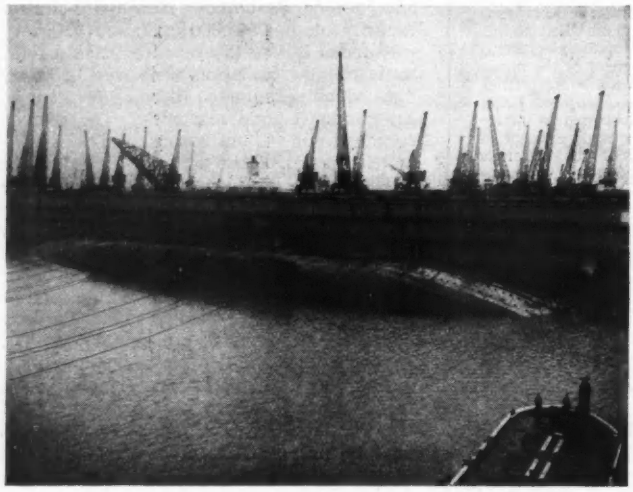


Fig. 12—Counterweight pontoons

Each pair of pontoons was blown or vented from a control panel on the quayside through 1in diameter flexible hoses, two per pontoon.

Counterweights.—Six A.S.P.s were suspended on the starboard bilge (Fig. 12). They were partially filled with water to bring them to the weight of 115 tons each, giving a total of 690 tons. They were positioned and ballasted so that they would float clear when the vessel reached an angle of 50 deg. to the vertical.

Each pontoon was suspended by two 7in wire pendants, cut and spliced to exact lengths, the outer ends of the wires being shackled to short lengths of chain passing through the hawse pipes of the pontoons and the inner ends secured by 6in pins in special tabernacles, welded to the shell plating where they would be above water when the vessel uprighted.

Internal Buoyancy.—In the original planning it had been intended to obtain the internal buoyancy by building internal bulkheads and pumping out the requisite amount of water. Following the divers' survey and a close examination of the condition of the decks above water, and taking account of the number of watertight bulkheads to be constructed, and the amount of shoring of the decks that would have to be done under water, it was decided to attain the required buoyancy by the use of compressed air. This would reduce the amount of under-water work, most of the work in making the various spaces airtight being above water. Eight separate compartments were made airtight as follows by the arrangement shown in Fig. 13.

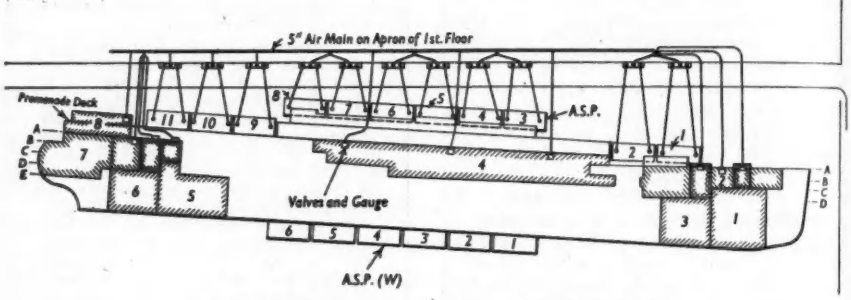


Fig. 13—Buoyancy compartments and pontoons, air supply

No. 1, No. 1 hatch trunk, between deck and hold (frames 168–184).

No. 2, No. 2 hatch trunk, between deck and hold (frames 149–168).

No. 3, forward crew accommodation spaces in "B," "C" and "D" decks and the deck house on "A" deck.

No. 4, passenger accommodation space on "A," "B" and "C" decks, between frames 68 and 139.

No. 5, after promenade deck and "A" deck house (frames 1–23).

No. 6, No. 6 hatch trunk, between deck and hold (frames 31–48).

No. 7, No. 7 hatch trunk, between deck and hold and the steering-gear compartment.

No. 8, after passenger accommodation space on "B," "C" and "D" decks (frames 1–36).

With the water expelled down to the centre-line of the ship, a total buoyancy of 4700 tons would be obtained from these compartments at an air pressure of 6 lb per square inch. This buoyancy in conjunction with the other forces provided a total uprighting moment only about 5 per cent in excess of the original estimated required moment and, for this reason, all spaces were made tight to a level about 9ft below the centre-line, providing an additional 3900 tons of buoyancy at a pressure of 10 lb per square inch.

A further advantage gained by the use of compressed air was that as the wreck altered its angle to the vertical, air would spill and the compartments reflood in the later stages of the operation, thus preventing the presence of excessive buoyancy when the vessel was upright.

Compressed air was admitted to the compartments through valves bolted to the starboard side, release valves and individual gauges being fitted for each compartment. The gauges were arranged so that they could be read from the central control position.

A large amount of work was involved in making these compartments airtight, particularly in the sections involving accommodation where it was necessary to strengthen the boundary bulkheads, locate and seal all service piping, ventilation ducts, &c., and strengthen the deck pillars, the decks, of course, being designed for external and not internal pressure.

The upper deck was steel originally planked with 3in teak, practically all of which had been burnt on the starboard side, and it was necessary to cut out many thousands of the bolts which had held the deck planking, and to plug the holes. All openings—portholes, doors, scuppers, &c.—in the starboard side were closed with welded plates throughout, whether needed for the air compartments or not, to reduce the work to seal the hull before final refloating.

TABLE I—*Summary of Schedules*

Item	Weights, tons	Keel gravity, ft	V moment	Longitudinal centre of gravity, ft	Moment, aft, ft-tons	Moment, forward, ft-tons
Light ship weight (modified)	15,562·0	34·00	529,108·0	24·0 A.	373,488·0	—
Items to be added	2,100·0		88,830·0		6,650·0	—
	17,662·0		617,938·0		380,138·0	
Items to be removed	3,242·0		135,127·0		76,360·5	—
Adjusted weight	14,420·0	33·42	482,811·0	21·07 A.	303,777·5	—

Compressed Air Supply.—In addition to the compressed air required for the pontoons and the eight compartments, compressed air was used to minimise the suction between the mud and the ship's port side in the initial movement.

To introduce this air, the divers shot a number of "Temple Cox" air bolts through the port shell plating from inside the ship at "D" and "E" deck levels, each bolt being individually supplied by a ¾in hose from the quay; in addition, a number of open-ended ¾in air hoses were placed by diver between the shell plating and the bottom. This was achieved by attaching the open end of the hose to a semi-flexible sectional drain rod, which was pushed from the deck edge under the ship to the required distance by a diver sitting on the dock bottom.

To supply the compressed air, a 5in bore pipe was laid on the first-floor apron of the dock shed, with 2½in connections to the pontoon control panels, individual connections operated from apron level to the eight buoyancy compartments and connections to the anti-suction fittings. The compressed air main was supplied from a battery of fourteen portable compressors in the shed and additional connections were made at the west end to the compressors on the two salvage vessels in case a larger supply was required if undue leakage occurred. All air pipes from the quay to the wreck were of sufficient length to allow the wreck to upright without breaking the air supply, the excess pipe being coiled on the quay and secured with light twine stops.

Calculations.—A fully detailed schedule of all items of weight removed was prepared and the position of each item relative to the vertical and longitudinal centre of gravity measured from the plans, and similar schedules prepared for amounts of wood bulkheads, panelling, furnishings, &c., burnt and stores burnt or removed, these schedules comprising several hundred items. Similar schedules were prepared for weights added by the construction of the tripods, shoring and stiffening of bulkheads, amounting to 350 tons of steel, the tripods accounting for 270 tons of this total. Allowances were made for mud settled inside the vessel based on divers' measurements in various spaces and for trapped water, also for the reduction in weight of structure and fittings below water level in the capsized position.

The summary of these figures is given in Table I, above. The accepted values were:

Weight of wreck ... ... = 14,500 tons
Keel gravity ... ... = 33·5ft
Longitudinal centre of gravity = 21·1ft abaft centre

The wreck lay at an angle of 89 deg. to the vertical, and the turning point was assumed to be initially at the point on the shell where the flat side joined the curved bilge plate, the lever about the turning point in this condition being 22·7ft, giving an initial upsetting moment of 329,150ft-tons. The upsetting moment and the uprighting moment from each of the uprighting sources was calculated for each 10 deg. up to 40 deg. from the vertical, when the vessel had an uprighting moment of 97,150ft-tons, the upsetting moment becoming zero at 50 deg. The results of the calculations are plotted in a graph in Fig. 14.

It was appreciated that as the wreck rolled on her bilge the soft mud overlaying the rock would be squeezed in front of the curved plating. This mud had an average depth of 5ft and it would have been possible to dredge it away, but it was decided to leave it as a cushion to retard the movement caused by the vessel's own weight from about 45 deg. inclination onwards, and minimise the risk of damage to the bottom shell plating which would have complicated the subsequent refloating operations.

The centre of the tripod pull was 14·5ft

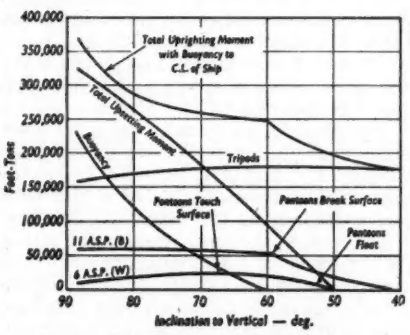


Fig. 14—Upsetting and uprighting moments

abaft the longitudinal centre of the ship, and therefore 6·6ft forward of the longitudinal centre of gravity, thus giving a moment tending to twist the wreck horizontally. The pressure on the port shell plating in contact with the ground was estimated to be 0·8 ton per square foot, which appeared to be a reasonable ground pressure to resist twisting or sliding on the initial pull. As an additional precaution, three wires 4in in circumference were secured at each end of the vessel about 180ft each side of the centre length at the deck level on the starboard shell plating, passing right round the hull under the ship and secured to bollards on the quay side.

The south quay was occupied on February 10, 1954, and the rigging of the wires across the dock was commenced, the weight pontoons having been previously placed in position by floating crane. Fig. 15 shows the lead of wires and positions of pontoons. All work on the wreck, including the testing of the air compartments and the placing of the buoyancy pontoons, was completed by the end of February.

The buoyancy pontoons were sunk into position, secured, and blown to full buoyancy to test the fastenings and stretch the wires. They were then vented, the securing wires retightened and finally secured. All winches were tested under steam for an extended run and bearings, &c., adjusted where required. The six vessels supplying steam were brought into position forty-eight hours in advance of the operation, and all piping and connections tested under pressure. The main control position was situated on the first floor of the shed on the north quay and connected by temporary telephones with subsidiary operational positions, the telephones being supplemented with portable very-high-frequency radio equipment. From this position all the tripod wires could be sighted and the gauges on the air compartments read with binoculars. A large pendulum with a scale graduated in degrees was erected on the starboard side forward of No. 1 tripod and observed from the east quay, the readings being telephoned to the central control (Fig. 16). To ensure simultaneous action by the individual winch operators, a revolving order board was erected on the south side of the south shed, in a position clearly visible from all the winches, orders such as "brakes off," &c., being painted in letters 2ft high and operated on telephoned instructions from the officer-in-charge at the main stop valve.

The operation was timed for 1230 hours on March 6, 1954. By 0800 hours all air compartments were blown to 6 lb per square inch and the pontoons blown to full buoyancy. The winches were declutched, the main drums being held on the brakes and run light, to ensure that they were properly warmed through and all water was cleared from the steam lines. Operating personnel were closed up at their various positions and checked. Emergency parties of fitters, burners, &c., with their equipment were sited at suitable points and the fire brigade and first-aid detachments were in attendance.

The order to start heaving was given at 1235 hours and the wreck commenced to turn as soon as the wires tightened. She continued to turn steadily (Fig. 17), reaching an angle of 45 deg. in fourteen minutes at 1249 hours, by which time heaving had to be stopped as the purchase blocks had come together, the movement of the wreck ceasing at 44½ deg.

No. 7 purchase was overhauled, the 9in pendant unshackled and the outer block connected to the main wire, and heaving with this one wire recommenced at 1315 hours. The wreck started to roll again, with a pull of about 80 tons, finally coming to rest at 9 deg. from the vertical at 1347 hours (Fig. 18).

The six buoyancy pontoons amidships had now been lifted out of the water and, as their weight was opposing the uprighting force, they were released. The pontoons weigh 42·5 tons each.

The vessel was then resting on the bank of mud squeezed towards her starboard side, and this amount of list was rather large for the refloating apparatus. As soon as the hauling wires were removed, a grab dredger

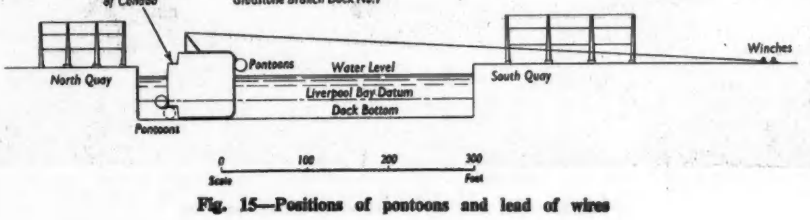


Fig. 15—Positions of pontoons and lead of wires

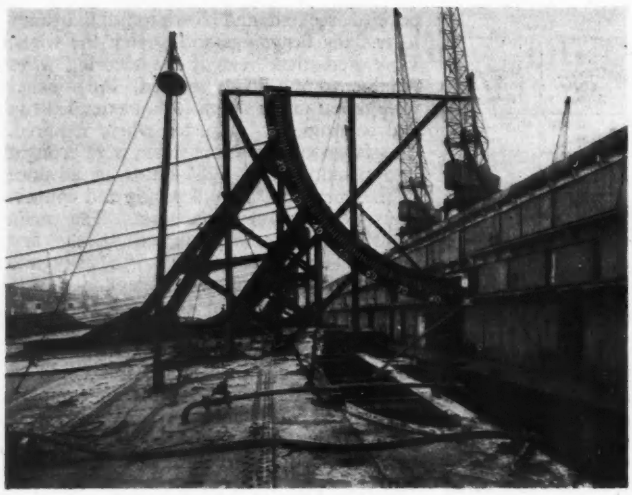


Fig. 16—Inclinometer

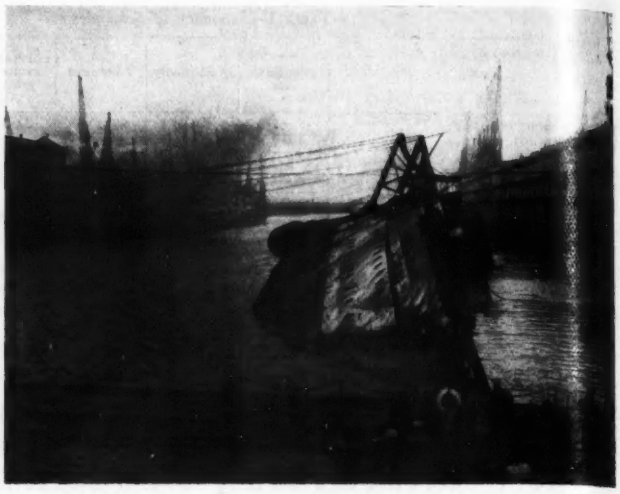


Fig. 17—List 77 deg.

removed the mud from alongside the starboard bilge, and two camels were moored under the tripods and each was secured by four 9in wires to the tripod heads. By flooding the tanks of the camels a weight of 800 tons was applied and the list reduced to 5½ deg.

Refloating.—The refloating problem was to bring the ship afloat in a stable condition and at a draught and trim convenient for drydocking. The level of the bottom towards the centre of the dock is 23ft below datum, and the level of the keel resting on the mud was 21ft below datum, the datum being the mean level of equinoctial spring tides. The calculated draught of the vessel after removal of mud and debris in the upper decks and with all tanks full was 21ft 9in. The range of a spring tide falling to datum level at low water would be 31ft, the elapsed time from low water to high water being only 5½ hours. Over the low water period the level of water in the dock would be at or below 21ft 9in for only one hour, there being no means of retarding the entry of the rising tide.

It was not possible to pump out the ship and ensure the removal of all loose water in the time available, and there would have been a serious risk of the vessel again capsizing. The method adopted was to ballast the vessel to a refloating draught of about 44ft, which would give a period of six to seven days during neap tides when the dock water level could be maintained at that height, giving ample time for correcting list and trim before drydocking, without any risk of capsizing, as the vessel need not be more than 1ft clear of the dock bottom. A weight of 29,000 tons of ballast would be required in the vessel to bring her to the required draught. Solid ballast would have had to be discharged before the vessel could be drydocked, which would have been a long and costly operation, but by ballasting with water these difficulties would be removed.

The plan adopted was to keep the lower holds and " E " deck flooded to the lower side of " D " deck (Fig. 19), with the engine-room and boiler-room flooded at the same level. By keeping the water level 2ft above " D " deck in the hatch trunks and sealing off the whole of " D " deck, the calculated metacentric height was 8ft, giving a reasonable margin for eventualities. The only large area of free surface was in the engine and boiler spaces.

With the water level in the vessel up to " D " deck the weight of water would be 24,900 tons, giving a mean draught of 41ft 8in and a trim of 9ft 6in by the head, this unbalance being due to the sheer of " D " deck —the main deck—the height of this deck above the level being 28ft 3in amidships, 37ft 6in at the forward end of No. 1 hold, and 32ft 3in at the after end of the after hold. To correct the trim and to counteract the anticipated list to port, 2000 tons of washed gravel was to be placed in " B " and " C " decks on the starboard side aft to give a draught of about 43ft 6in on an even keel.

The first operation was to seal all the openings, portholes, doors, scuppers, &c., on the port side, as all openings on " D " deck and a large number on " C " deck would be submerged at a draught of 43ft 6in. To reduce the amount of diving work, the dock was run down to low water level for two tides and blanks were welded over 184 portholes. Two shell doors in " C " deck and the oil fuel filling door in " D " deck were also welded. The dock water level was liable to fluctuate in normal operation by as much as 10ft, and a fall of 10ft would cause an additional 11,000 tons of water to be retained in the vessel. To permit rapid equalising of the interior and exterior water levels eleven 14in sluice valves were fitted in " C " deck controlled by rod gearing extending up to " A " deck. The amount of mud and debris was considerable, and over 3000 tons was discharged by hand into barges for dumping at sea, the work being rendered more difficult by the presence of quantities of oil fuel.

The upper decks down to " B " deck were above water level for the greater part of the time, but work on the lower decks, including the sealing of " D " deck, had to be done compartment by compartment to avoid the wreck becoming too buoyant.

" D " deck was the main deck for classi-

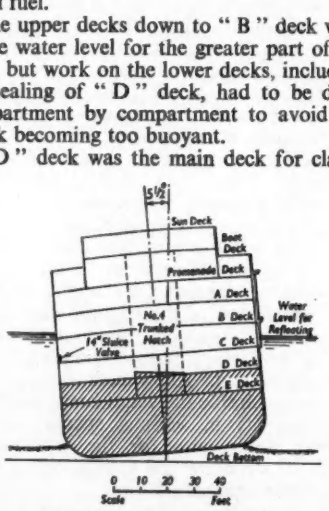


Fig. 19—Refloating diagram

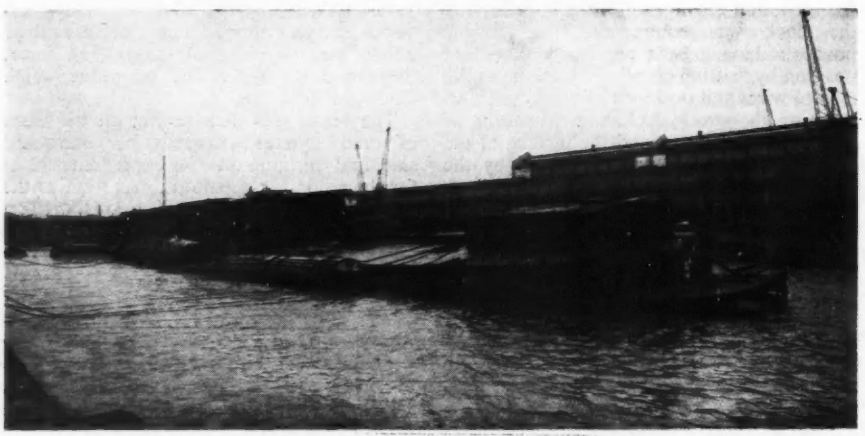


Fig. 18—View from aft at end of uprighting operation

fication purposes and was therefore a watertight deck. The spaces in the deck at the ship's side round the frames had, however, been sealed with cement chocks, and a large number were broken and loose through the effect of the fire. This deck would have to withstand a water pressure from the underside of up to 4 lb to 5 lb per square inch, and as it was essential that there should be no leakage into " D " deck, it was necessary to weld fitted plates round each frame after clearing the loose cement. This work had been completed along the starboard deck edge while the vessel was on her side, but the whole of the welding on the port side had to

be done in sections by pumping out the compartment, cleaning and welding.

The tripods were left in position and four empty pontoons were placed on the tripods for the initial refloating attempt, the width of the entrance to the Gladstone graving dock being sufficient to enable the vessel to enter with the tripods in position. A pendulum, 18ft in length, terminating in a heavy plumb-bob with a pointer, was placed in what had been one of the public rooms on the promenade deck amidships, the deck being marked out so that list and trim could be read directly, this central control position being linked by temporary telephones with the various pumping stations.

The initial trial was made on June 23, but it was found that there was an excess of weight to starboard. The pontoons were lifted off and the tripod legs burnt through and the tripods removed.

On June 27, seventeen months after she sank, the vessel was refloated with a list of 2 deg. to port and trimming 2ft by the stern. By the removal of 200 tons of the shingle ballast, and adjustment of water levels, she was brought to an even keel on a draught of 42ft 1in with a list of 1 deg. to port.

In the early hours of July 1, she was towed to the graving dock and landed on the blocks. Her displacement in this condition was 40,250 tons and to avoid excessive pressure on the keel and bilge blocks, the water in the graving dock was pumped down to 27ft over the blocks and then lowered concurrently with the water being pumped out of the holds and boiler-rooms.

The examination of the hull showed that the only damage caused in the uprighting had been to the port bilge keel, 60ft having been torn off and the remainder bent back flat against the shell plating. The vessel was sold to Italian shipbrokers, and after removal of the propellers and various other work to prepare her for towage overseas, left the port on September 1.

Conclusion

The operation was directed by the staff of the marine department of the Mersey Docks and Harbour Board in collaboration with the Board's Engineer-in-Chief, M.I.Mech.E., M.I.C.E., and the consulting naval architects, Messrs. T. R. Little and Co.

The construction and erection of the tripods and welding, &c., in the vessel was done by the ship repair department of Harland and Wolff, the remainder of the work being carried out by the Board's personnel.

Traction-Engine Railway Locomotives

By R. A. S. ABBOTT

No. I

THE geared steam locomotive for industrial uses has been produced in many different designs for over a century, but the purpose of this article is to place on record all available information relating to that unusual type of geared locomotive built mainly by the various well-known traction-engine makers in Great Britain, and about which very little has been published. Engines of this type have never before been dealt with collectively in the technical press and for this reason it is hoped that these notes will prove of interest to the historically minded engineer, and fill a niche in the literature of the locomotive.

Mechanically they possessed few outstanding features and indeed appear crude and clumsy machines in this day and age, but there is no doubt that these locomotives have played a very useful and important part in the transport economy of many industrial undertakings where a locomotive possessing good adhesive qualities at low speeds, with light weight, was required, and they were very favourably received by the cement, brewing, gas and brick industries.

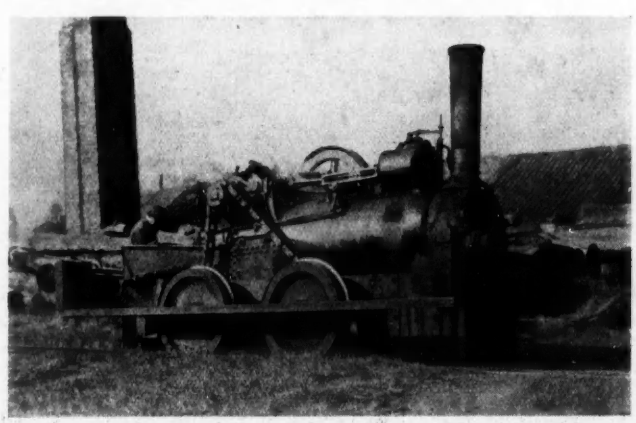
As a result of researches made by the author over a number of years it is now possible to illustrate and describe locomotives of traction engine type built between the early eighteen-sixties and 1924 by eleven different firms.

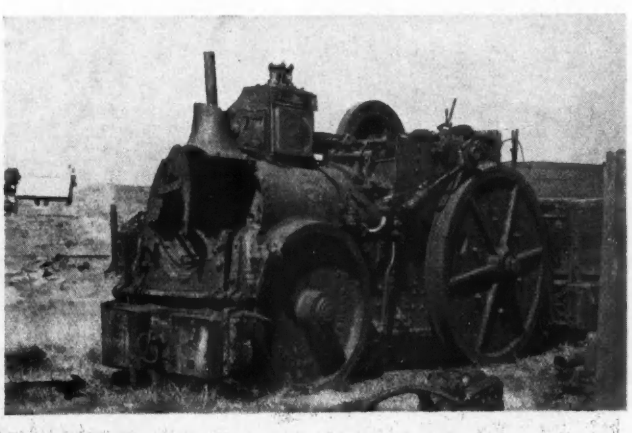
The earliest example of a locomotive of this design known to the author was the "Rattlesnake" built in the early eighteen-sixties by I. W. Boulton at his Portland Street Works, Ashton-under-Lyne, a firm whose activities have been so ably recorded by the late A. R. Bennett in *The Chronicles of Boulton's Siding*. The "Rattlesnake" is illustrated on page 99 of the above book, and had the two cylinders enclosed in the upper part of the smokebox, with the crankshaft supported on brackets secured to the boiler barrel, and had a steam dome placed on the firebox. The four coupled-wheels were 3ft 3in diameter; wheelbase, 6ft 6in; overall length, 18ft 9in; height to top of chimney, 12ft 9in. Power was transmitted to the wheels by pitched chains, one sprocket on each end of the crankshaft driving through a 2 to 1 reduction two chain wheels on the leading axle. These chain wheels were located between the driving wheels and the frame, and the four flanged wheels were coupled by normal side rods. Water was carried in two tanks, one under the boiler and one under the smokebox. The back-plate of the firebox was unusual in that it was flanged outwards.

Fig. 3—Aveling and Porter narrow gauge locomotive with external chain-drive

Speed was about 10 m.p.h., and the hauling capacity about ten full tip wagons on a grade of 1 in 70.

The first locomotives, based on traction engine practice, built by the firm of Aveling and Porter, Invicta Works, Rochester, appear to have been some four-wheeled coupled chain-driven locomotives introduced towards the end of 1865 or early 1866. The engines were rated at 10 n.h.p. and had a single cylinder 10in diameter by 12in stroke, with wheels 4ft diameter on a wheelbase of 5ft 3in. From the crankshaft, mounted over the firebox, the motion was taken by spur gearing on the left-hand side to a counter-shaft carrying at its end the sprocket wheel for the pitch chain, the bearings for this shaft being placed in curved slots formed





Figs. 1 & 2 (Left)—Chain-driven locomotive, built in 1872 for the Duke of Buckingham's Oxford and Aylesbury Tramroad. (Right)—Narrow-gauge locomotive "Excelsior," built in 1880 for Jas. Whittaker and Son, Shuttleworth

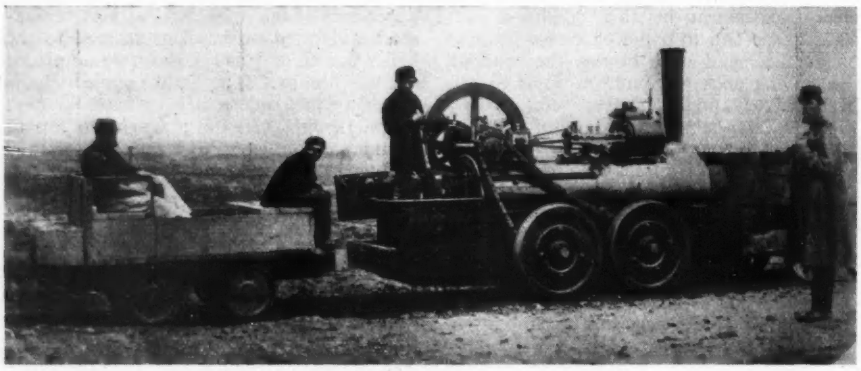


Fig. 4—Aveling and Porter chain-driven narrow gauge locomotive

in the supporting brackets, so that the shaft could be raised and the chain tightened when necessary.

The pitch chain extended from the countershaft round both the chain wheels fixed on the inside of each right-hand driving wheel. The boiler tubes, sixty in number, were 5ft 6in long and 2¼in diameter ; external heating surface, 194 square feet; the firebox, 3ft long and 2ft 7in wide by 2ft 7in high, provided 28 square feet of heating surface. Total heating surface 222 square feet. Grate area 7·75 square feet. Boiler working pressure 80 lb per square inch. Boiler fed by pump. There were two water tanks, one at the front and a second under the coal bunker, total capacity about 350 gallons. Coal 10 cwt to 20 cwt according to mode of packing. Total weight 9 tons. Price, in 1866, £530.

From *Engineering*, August 3, 1866, we learn that three locomotives of this type had been supplied to the Grays Chalk Quarries Company, and were reported to be giving very satisfactory service. Other locomotives of this design were supplied to the Halling Lime Works ; the Lamb Wharf Chalk Works, Greenhithe ; the Royal Dockyards at Chatham, Devonport and Portsmouth ; to Brisbane and to India.

Perhaps the most widely known of these locomotives were the two supplied in 1872 to the Oxford and Aylesbury Tramroad in Buckinghamshire, later the Brill branch of the Metropolitan Railway. Both these were eventually sold to the Heyford Brickworks near Weedon, one being scrapped almost immediately and used as a source of spare parts for the other, Fig. 1, which was in daily use until early in 1940. After lying idle for eleven years it was, at the author's instigation, acquired by the Industrial Locomotive Society, and later presented to the London Passenger Transport Board which has now removed it to Neasden Works, where it was overhauled and repainted, during 1955-56.

This design was eventually built in 46, 8, 10, and 12 n.h.p. sizes, and to special order up to 20 n.h.p.

For narrow gauges, Messrs. Aveling and Porter introduced two variations of this chain-driven locomotive. The small locomotive in Fig. 4 had the firebox overhung behind the rear axle with a short wheelbase, a design which allowed a firebox of adequate size to be used.

From particulars given in a catalogue of 1870, it would appear that this locomotive was of 4 n.h.p., had wheels of 3ft diameter, weighed 5 tons, and could draw a load of 30 tons.

The second narrow-gauge design (Fig. 3) had the chain wheels placed outside the driving wheels, thus providing sufficient space for a boiler and firebox of reasonable size.

The next type to be introduced was the 2–2–0 design early in the 1870s, for in *Engineering* of November 21, 1873, there is a reference to nine Aveling and Porter engines being in use by the Royal Engineers at Chatham depot. These locomotives were supplied with two sets of wheels ; one set for road work and a set of flanged wheels for use on the railway from Upnor to the Government powder magazine. At this time the Ashanti expedition was being sent out to the Gold Coast, and three Aveling 5-ton "Steam Sappers," as used by the Royal Engineers, were despatched together with ten light cars and eight wagons, but as it was thought that a railway might be a practical proposition, the engines and stock were made convertible, and spare sets of flanged wheels, together with 6½ miles of 24-lb rails were sent out. The gauge was to be 4ft 8½in. Whether the line was ever constructed is doubtful, but it might have been used for handling stores, &c., at the coast depot.

In order to reduce the overall width of these convertible engines, Thomas Aveling obtained a patent, No. 197 of 1878, covering an arrangement of gearing in which only the driving spur pinion was outside the hornplates. Hitherto it had been the practice to place the driving gear between the boiler and driving wheels, which necessitated a great overall width, and this had restricted the size of the early convertible locomotives. To provide for the narrower railway gauge without altering the dimensions of the boiler on locomotives of 6 n.h.p. and upwards, the gearing was now rearranged for working with two speeds within the width of the firebox and hornplates, and all gear wheels were keyed firmly on their shafts, thus avoiding the inconvenience due to the use of pinions sliding on feathers.

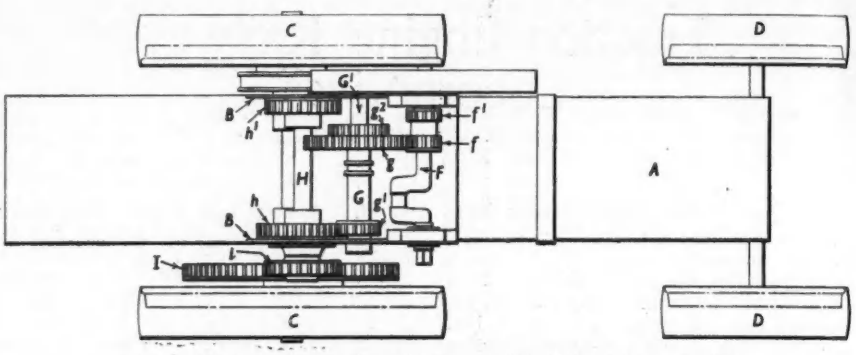


Fig. 7—Diagram of gearing as applied to convertible "Steam Sapper," 1878

The view, Fig. 7, which is a reproduction of the drawing accompanying the patent specification, shows a locomotive fitted

Fig. 5—Locomotive built in 1881 for Lees Cement Works, Halling

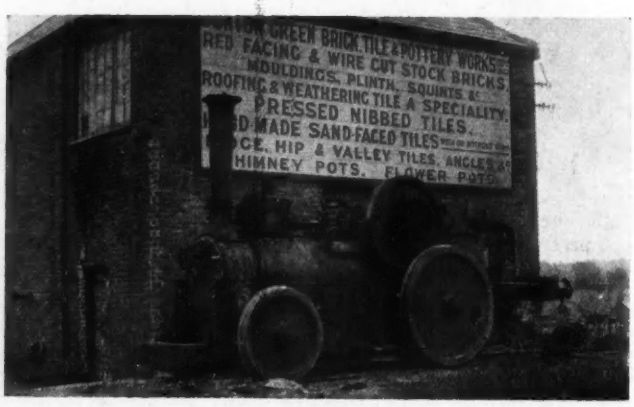

RED FACING & WIRE CUT STOCK BRICKS
MOULDINGS, PLINTH, SQUINTS &
ROOFING & WEATHERING TILE A SPECIALITY.
PRESSED NIBBED TILES.
HIP & VALLEY TILES, ANGLES &
HIMNEY POTS, FLOWER POTS

Fig. 6—Locomotive built in 1882 for Dunton Green Brick Works

with gearing according to this plan. *A* is the boiler and *BB* the hornplates extending above the boiler and firebox to receive the bearings for the crankshaft and intermediate shafts. *CC* are the driving wheels and *DD* the front wheels ; *F* is the crankshaft.

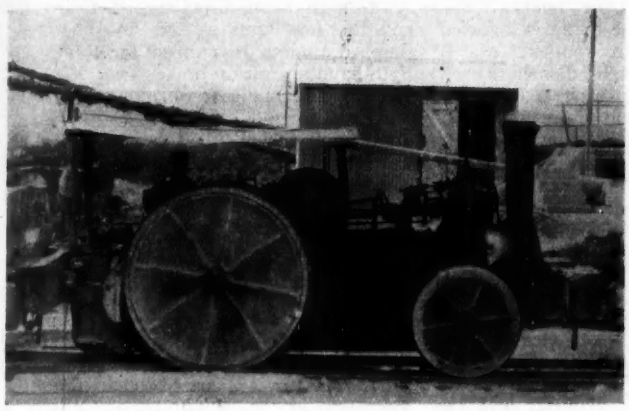
The crankshaft is fitted with two pinions *f* and f^1 of equal diameter, which are intended respectively to engage a spur wheel *g* made fast to a sleeve *G* that is free to slide under the action of a horizontal hand lever, on a "dead" countershaft G^1 made fast to the hornplates *BB*.

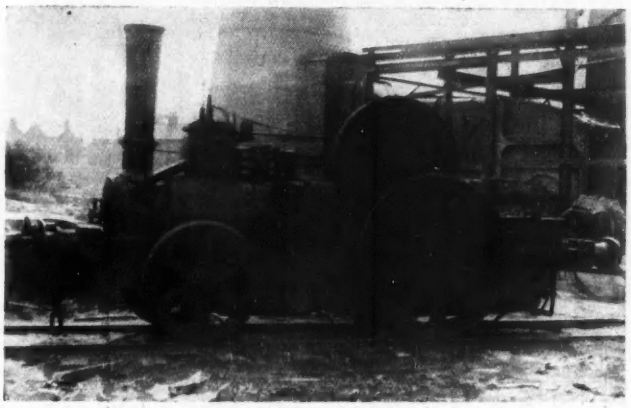
On the sleeve *G*, which carries the spur wheel *g*, are also mounted two pinions g^1 and g^2 of different diameters, and on a second countershaft *H*, having its bearings in the hornplates, are mounted two wheels *h* and h^1, which are intended respectively to gear into the pinions g^1 and g^2 on the sleeve *G* according to the speed required. On the end of the second countershaft *H*, outside the hornplates, is fitted a spur pinion *i* gearing into the large spur wheel *I* on the driving axle.

In the position shown in Fig. 2 the gearing is in the "slow" position. When, however, a quicker speed is required this is effected by shifting the sleeve *G* on the first "dead" countershaft so as to bring the pinion g^2 into gear with the spur wheel h^1 on the second countershaft *H* and at the same time shifting the wheel *g* out of gear with the pinion *f* and into gear with the pinion f^1 on the crankshaft *F*.

This arrangement allows of the pinions *f*, f^1 and g^1 and the wheels *h* and h^1 being flanged or shrouded on one side. By employing a sleeve on the "dead" shaft G^1 the use of pinions sliding on feathers is dispensed with. The time required to change the driving and leading wheels, which for railway work weighed 18 cwt and 6 cwt respectively, was two hours.

A photo of one of these "Steam Sappers" appears in the *Journal* of the Junior Institution of Engineers for March, 1929. This convertible design seems to have been confined to Army uses, but the 2–2–0 type proper for railway use only was favourably received by industrial concerns in this country and it continued to be built by Aveling and Porter as late as 1921. Five of the accompanying illustrations show examples of this design covering a period of forty-one years. The locomotive in Fig. 2, the "Excelsior" (Works No. 1607 of 1880), was built for the 3ft gauge lines of Messrs. Jas. Whittaker and Son, Scout Moor, Shuttleworth, and is remarkable in that both the flywheel and the gearing is placed behind the driving wheels despite the narrow gauge. The very poor condition of this locomotive may be explained by the fact that it has stood in its present position, out of use, since about 1918. Locomotive No. 1681 of 1881 (Fig. 5), was supplied to Lees Cement Works, Halling; Fig. 6 shows the Dunton Green Brick Company's engine, No. 1740 of 1882. The locomotive "Venture," Fig. 8, was built for Peters Bros., cement manufacturers, in 1890, Works No. 2640 ; finally in Fig. 9 we have the omega of the type, No. 9449 of 1921, supplied to the Holborough Cement Company between Halling and Snodland. The dimensions, of course, varied according to different requirements and gauges, and some locomotives had the two-speed gear change, whilst others were single speed only, but it will be sufficient to quote the leading particulars of an engine built in 1892 for the 4ft 3in gauge :— cylinders, 11in diameter by 12in stroke ; driving wheels, 6ft diameter ; leading wheels, 4ft diameter ; boiler contained fifty-eight tubes of 2in diameter, 5ft 10¾in long ; total heating surface, 212 square feet ; grate area, 7 square feet ; working pressure, 115 lb ; weight, 11 tons 13 cwt. It will be observed that this single driving wheel type exhibits an intriguing variation in wheel design. The hauling capacity of these engines was about 90 tons.





Figs. 8 and 9—(Left) Locomotive "Venture," built in 1890 for Peters Brothers, cement manufacturers. (Right) Locomotive built in 1921 for the Holborough Cement Company

At the Derby Agricultural Show in 1881 Messrs. Aveling and Porter exhibited a locomotive for operating street tramways. This locomotive (Fig. 10) was of the 2–2–0 type and had 5ft driving wheels of cast iron with the spokes of "H" section, and was a tandem-compound built after the patent of Mr. G. Kingdon, of Kingswear, Devon.

The cylinders, 5½in and 11in by 10in stroke, were mounted at the smokebox end of the boiler and were both steam jacketed, the jacket forming the dome and the steam being taken from the upper part to the one slide valve which served both cylinders. In place of a stuffing-box between the two cylinders there was merely a gun metal bush held between two plates, that portion of the piston-rod between the two pistons being grooved circumferentially, the effect of these grooves being to prevent leakage of steam between the rod and bush. It should be noticed that when the engine was at work the adjacent ends of the high and low-pressure cylinders were in free communication through the steam passages when the pistons were moving towards the crank, and any leakage which might occur along the piston-rod would be of no consequence. On the other hand, when the pistons were moving from the crank there was considerable difference of pressure on the two sides of the bush traversed by the piston-rod, and as the latter was moving towards that cylinder in which the higher pressure existed this movement undoubtedly tended to reduce any leakage because the motion of the rod towards the high-pressure cylinder carried back into that cylinder any steam which might have found its way into the grooves.

The gear ratio was 7 to 1 and the crankshaft was geared direct to the driving wheels without the use of a countershaft ; the crankshaft pinion engaged with a spur ring of steel bolted to the inside of the right-hand driving wheel. To enable the engine to be mounted on springs and at the same time to ensure that the crankshaft pinion and spur ring were always in correct mesh, the two bearings of the crankshaft and also both bearings of the driving axle were mounted on one cast steel frame, this frame sliding in guides fixed to extensions rearwards of the side plates of the firebox casing. The locomotive's small front wheels ran free on the axle, which was supported by a transverse spring.

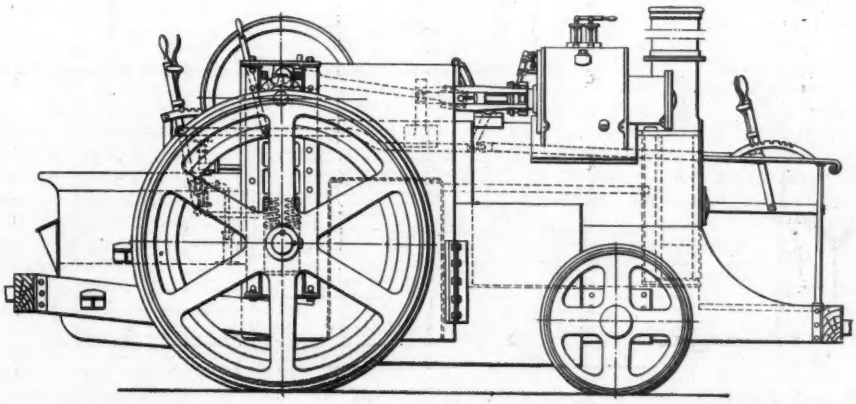


Fig. 10—Experimental tramway locomotive exhibited at Derby Agricultural Show, in 1881

The boiler barrel was 3ft in diameter and very short, the fifty-eight tubes of 2in diameter being only 3ft 9in long. These tubes provided a heating surface of 114 square feet, to which the firebox added 26 square feet, making a total heating surface of 140 square feet. Grate area 5 square feet. Two Ramsbottom safety valves were mounted on top of the cylinders and there were two water tanks, one at the front end and the other under the coal bunker, while the feed was by one pump and one injector.

A second footplate and duplicate reversing lever was provided in front of the smokebox. The present firm of Aveling-Barford has T. Aveling patent. The contemporary woodcut and drawing (Figs. 11 and 12) illustrate this locomotive, which was built for the 3ft 6in gauge and weighed 10 tons.

The total length was 11ft 6in, overall width 5ft 8in, height 9ft 6in, wheel base 4ft 6in. The boiler of steel, and double riveted, contained seventy-eight steel tubes 1½in diameter, total heating surface 148 square feet, grate area 5 square feet. Pressure 180 lb per square inch. The two cylinders, mounted on the firebox, were 5½in by 10in stroke, with the valve chests placed outside.

The crankshaft had a diameter of 3¼in and upon it was fixed a pinion wheel 9in diameter which geared into an intermediate wheel 3ft 4in diameter, revolving on a stud shaft fixed to the side of the boiler; this wheel again geared into toothed wheels 2ft 3in diameter, fixed on each axle. The ratio of the crankshaft to axles was 3 to 1. The ordinary system of springs had to be abandoned so that the crankshaft and axles could maintain their relative distances, so to take up the jar from the rails, wheels with self-contained springs were introduced. The driving wheels were 3ft diameter and the spring acted on the movable tyre, giving a play of about ¼in to ⅜in. These spring wheels were a modification of those which Aveling and Porter had previously used on their road traction engines. The steam from the cylinders passed into a tank on the footplate and then into a condenser on the roof containing a number of 1in tubes placed transversely and exposing a condensing surface of 208 square feet. The ends of the tubes led into longitudinal boxes with divisions, to cause the steam to pass to and fro in its passage from one end of the condenser to the other; the steam entered the condenser at the firebox end and any surplus passed down a pipe into a tank fixed below the footplate at the smokebox end. In this tank any water mingled with the steam was separated, and such steam as remained uncondensed passed to the exhaust nozzle arranged in the chimney in the usual way. To assist condensation, a fan was arranged to exhaust the air from amongst the tubes, a continuous stream of cold air being thus induced athwart the tubes; a special feature in the arrangement was the manner in which the Blackman fan was placed vertically so as partially to overlap the top of the chimney. It thus helped to exhaust the smokebox, ensuring the necessary draught and, moreover, effecting a thorough mixing of the hot gases with any uncondensed steam. The fan was driven by a small vertical engine placed alongside the chimney.

The tank on the footplate fed an injector and the low tank at the smokebox end supplied a pump driven from the crankshaft. Both hand and steam brakes were fitted and also an automatic gear which shut off steam and applied the brakes when the speed exceeded 9 m.p.h. This locomotive afterwards became No. 3 on the Brighton District Tramways.

(To be continued)

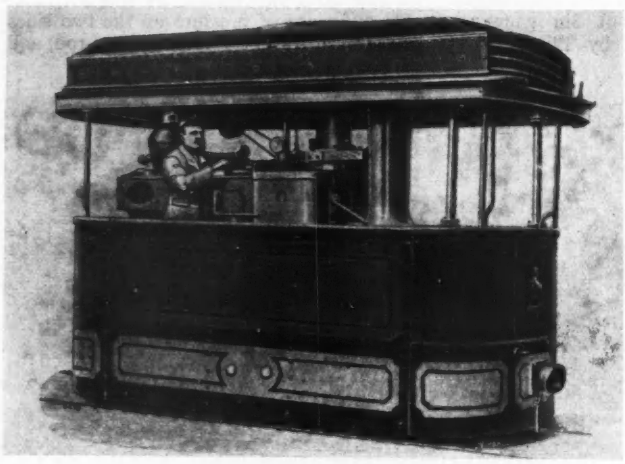


Fig. 11—Greig and Aveling patent tramway locomotive built by Aveling and Porter in 1887 for Brighton

not been able to trace whether this interesting locomotive ever worked on a public tramway in this country or whether any others of the same type were built.

The next design of tram engine by Aveling and Porter was rather more conventional, although closely allied to traction engine practice.

Engineering for October 21, 1887, reported that some experiments were being made on a length of about 4 miles of horse tram road at Southwick near Brighton, with a steam locomotive built under an Alfred Greig and

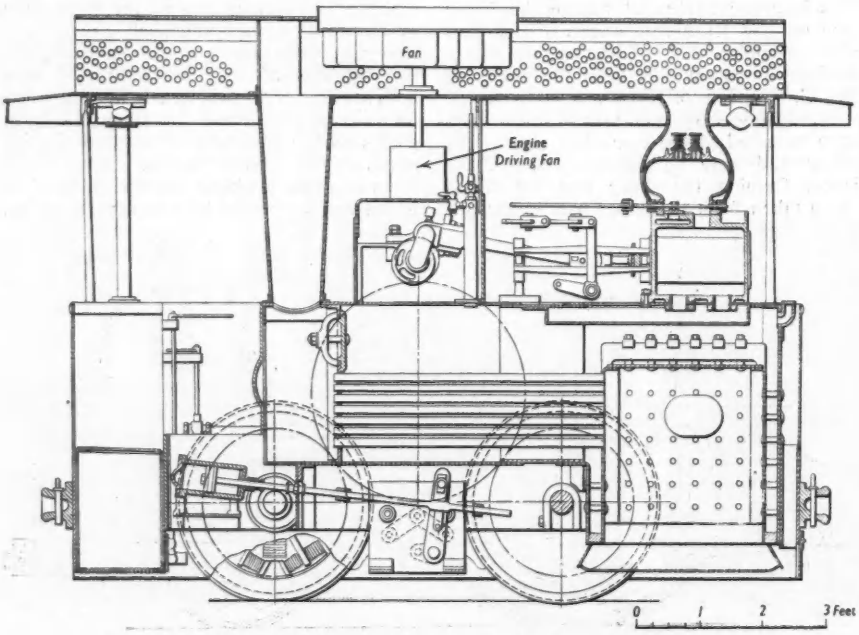


Fig. 12—Greig and Aveling tramway locomotive built in 1887 for Brighton

Imperial College of Science and Technology

THIS year the Imperial College of Science and Technology is celebrating the jubilee of its establishment by Royal Charter in July, 1907. The Royal Charter brought about the federation in the new Imperial College of three colleges of earlier origin which had settled in South Kensington in the latter part of the nineteenth century, namely, the Royal College of Science, the Royal School of Mines and the City and Guilds College. The Royal College of Science owed its origin to the Royal College of Chemistry, of which the Prince Consort was the founder, in 1845, and first president. The Royal School of Mines was founded in 1851 as the Government School of Mines and of Science applied to the Arts. The City and Guilds College was founded in 1884 by the City and Guilds of London Institute. These three colleges came together in 1907 in the Imperial College, the purpose of which, in the words of its Charter, is "to give the highest specialised instruction and to provide the fullest equipment for the most advanced training and research in various branches of science, especially in its application to industry." It may be recalled that in a Parliamentary reply in January, 1953, the Financial Secretary to the Treasury said that the Government proposed to put further resources at the disposal of the University of London for the purpose of major expansion of the Imperial College of Science and Technology. He went on to say that this development of Imperial College would be in pursuance of the policy already announced by the Government of building up at least one institution of university rank devoted predominantly to the teaching and study of the various forms of higher technology. The first major building project to be completed in this expansion programme is the Roderic Hill building for aeronautics and chemical engineering. An important event in the jubilee celebrations will be the visit, on May 28, of Her Majesty Queen Elizabeth the Queen Mother, who, as Chancellor of the University of London, will open the building. At the jubilee dinner to be held at the Mansion House on May 27, Lord Salisbury, Lord President of the Council, is to be the guest of honour.

Machine Loading—An Industrial Application of Computers

By C. M. BERNERS-LEE*

Some work has been done by Ferranti, Ltd., on the possibilities of using computers for solving the problem of scheduling production in a general machine shop. The scope of this work is briefly discussed in the belief that the method applied here to a particular problem may have wider industrial applications.

THERE has been a tendency to classify the applications of computers as scientific or commercial. It is becoming increasingly clear, however, that there exists a third major subdivision of the field which is of sufficient importance to be distinguished as neither entirely scientific nor exclusively commercial in character, and which may be called the industrial field. It is commercial, in that it deals with day-to-day operations in the workshops and on the production line. It is also scientific in that the work in this field is being pioneered by planning engineers, industrial statisticians and operational research men.

The problems which arise in this industrial field are of considerably greater subtlety than those which derive from the processing of routine paper work. The objective is to increase the throughput of the shops by more effective planning. The approach often adopted is to treat the production process as if it were a mechanical system which is being subjected to a series of random shocks, and then to ask what effect changes in the parameters defining the system will have on the average in the long run. An example of a parameter whose variation may be studied in this way, is the warning level in a stock control system. If the warning level is too high, unnecessary surplus stock will be carried, and if it is too low, output will be lost through shortages.

If, for example, it were possible to process a long and representative stream of orders repeatedly, with varying warning levels, and to calculate the losses and gains each time, it would be feasible to arrive at a more profitable choice of warning level than is possible by any "common sense" method which must necessarily be somewhat arbitrary. It is, in fact, possible to do just this kind of thing by using a computer to simulate the processing of a long stream of orders under many different conditions. This example is only one of a general class of such problems. The approach is basically similar, whether one is dealing with stock levels, or some quite different process, such as cutting up rectangular sheets in the best way, or running a bus service in the most regular manner.

A considerable amount of study of this kind has been done in the U.S.A., where there is at least one firm of consultants with their own computer for this type of work. In this country, two such studies have been done on the Ferranti Mark I machine at Manchester, and two more will be starting shortly on the "Pegasus" computer in London.

Sometimes the object of study is to examine the effect of varying the parameters in an existing system. Other studies may be designed to investigate the feasibility of a quite different way of doing a job. Thus a computer may be used on a small scale to investigate the consequences of using a computer system for controlling operations on a large scale.

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Machine Loading—An Example

The main difficulty in approaching the industrial problem is usually that of finding a satisfactory way of formulating the objective in terms which are capable of being translated into a computing routine. It is thought that a detailed example of one way in which this can be done for a familiar case will be of value in stimulating further study.

There seems to be fairly general agreement that the way the sequencing is done at the moment in many general machine shops could probably be improved upon considerably, with perhaps a gain of several per cent in the throughput of the shops. This would pay for a computer handsomely and it certainly seems that there is a good case for trying to see how it might be done.

Suppose that we have a general machine shop which is making components for a variety of different assemblies, to be put together in an assembly shop. This latter shop is assumed to be making to order on a jobbing basis. This is the most common case (it is also the most difficult case, the mass production problem being very straightforward by comparison).

We shall assume that orders for sale come into the planning department, who allocate an order number to each final assembly, and who break down this order into sub-orders for components.

When the order is accepted, the date of acceptance, A, is recorded. The planning process loads the sub-orders on to machine centres in the machine shop. As a result of this process, it is found that the final assembly will be available for delivery at time T, say.

Penalties for Delay.—To enable a computer to decide between alternative plans it is necessary to set up a system of penalties to penalise late deliveries. Suppose a penalty function $V(T-A)$ is associated with each final assembly. The planning process will be designed to minimise the sum of the V's for all assemblies.

The construction of the functions V is very much open for discussion. One method is simply to take any steeply increasing function of $T-A$, for example,

$$V(T-A)=S(e^{\frac{T-A}{\sigma}}-1) \quad . \quad . \quad . \quad (1)$$

where S is the selling value of the final assembly, and σ is a time-scale constant, the same for all assemblies.

It may, however, be necessary to take into account other factors besides the selling value of the assembly. For example, the shipping situation or the expiry of an export licence may make it imperative that certain assemblies should be available before a certain date, so that the penalty should rise very steeply near this date.

It has been argued that the penalty function should, as far as possible, reflect the actual cost of delayed delivery. There are difficulties here, as it is not easy to evaluate the market repercussions of late deliveries. What seems certain, however, is that an operational research study is more likely to throw light on the best form for the penalty functions than any purely theoretical argument.

Minimising the Penalty.—We have to decide on a technique for minimising the total penalty as far as possible. It is, of course, theoretically possible to select the minimum-penalty plan. However, this might mean asking the computer to investigate an enormous number of possibilities which would take even a very fast machine a quite preposterous time. It is not at all difficult to set even an electronic computer an impossible task. For example, Fig. 1 shows a simplified version of the writer's problem in getting to

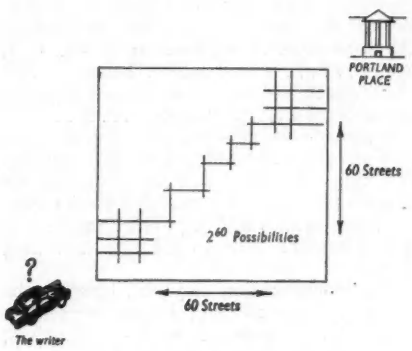

Fig. 1—A traffic problem

work by car in the morning. There are sixty streets running north and south and sixty east and west. There are two choices at every cross roads (north and east), so there are 2^{60} or about 10^{20} ways of getting to work every morning. Given the time of traversing each street (in general different due to differing traffic densities) any computer could happily spend its life attempting to reach the answer without getting very far.

There are certain problems for which it is possible to arrive at the optimum solution by evaluating only a very small proportion of the possibilities. Linear programming problems are of this kind.[1] Here one is seeking to maximise a linear function of a set of variables when these variables are subject to a number of linear inequalities. Geometrically, this corresponds to seeking the summit of a convex polyhedron. The method is to climb up successive edges, choosing the steepest edge at each vertex. It is thus not necessary to visit every vertex of the polyhedron to get to the top. A more familiar example arises during the washing up. Suppose it takes the washer-up a_i seconds to wash up the i^{th} item, and the drier-up b_i seconds to dry up the i^{th} item, in what sequence should the items be dealt with in order to minimise the total time? It has been shown (Ref. 2, quoted in Ref. 3) that for an optimum arrangement, the items should be washed and dried in the same sequence, and that if the i^{th} item precedes the j^{th}, then the least of a_i and b_j must not exceed the least of a_j and b_i. These rules can be used to enable a computer to arrange the items in the optimum sequence very rapidly. A programme for the optimisation of such a two-stage process has been written for "Pegasus."

In many cases, however, there is no such clearly defined route to the optimum, and this appears to be so with most practical machine loading problems. These normally involve multi-stage processing, and also often require the effects of changes in component sequencing on the delivery of final assemblies to be taken into account. However, even if the exact optimum is not attainable in a

feasible number of steps, it may, none the less, be possible to devise a practicable means of getting very close to the optimum. Thus, what we might hope to do is to find not the best possible way of sequencing the work in the shops, but one which is fairly near the best and is at any rate significantly better than can be found by manual methods in the time available. It will be better because many more possibilities will have been examined. A technique for achieving this limited objective is next described.

Queue Scanning.—As the orders for assemblies come in they are broken down to sub-orders, and these sub-orders queue up to be dealt with by their respective machine-centres. Each sub-order requires a particular machine setting. Let us number the sub-orders in a particular queue, 1, 2, 3, ... i . . . . n, sub-order 1 being the first in the queue, and let us denote the corresponding machine settings by S_1, S_2, ... S_i . . . . S_n.

Wherever two adjacent suborders (say, the i-1th and i^{th}) have different machine settings (i.e. $S_{i-1} \neq S_i$) there will be a changeover delay. Normally in a machine shop orders with like settings will be grouped together to a large extent in order to minimise this setting delay.

This consideration may not, however, be the only factor affecting the arrangement of the queue. Suppose a new sub-order arrives, it may happen that it is a very urgent sub-order which is holding up a final assembly whereas all the other orders are for assemblies which are held up for other components. Alternatively, it may happen that the reverse is the case, i.e. that the new sub-order is for an assembly which will be held up for a long time in any case. In either of these circumstances it may not necessarily be best to put the order with its fellows of the same machine setting.

The proposed method is that as each new sub-order arrives it should be fitted into the queue in the position which minimises the total penalty, both for the delay of the final assembly of the new order and for the additional delay caused to the assemblies whose components are in the queue after the new sub-order, taking into account any increase in setting delay which arises. A computer would thus be used to scan the queue, calculating the penalty which would be incurred from fitting the new sub-order into each possible position. It would then fit each new sub-order as it arose into the minimum penalty position and would output a list of sub-orders for each machine centre, arranged in order of priority.

This process will not in general lead to the minimum penalty solution, as the rearrangement of the entire queue is not contemplated, but it should give a plan which is fairly near the optimum and which is certainly far better than could be derived from any manual process. Moreover, this scanning process is sufficiently straightforward to be carried out by a fast computer routine.

The Place of the Computer in the Organisation

Having established a principle on the basis of which a computer routine for allocating priorities can be written, consideration must be given to the data required to carry out the process, the way in which this data is to be fed to the machine, and the frequency with which the process must be carried out. Fig. 2 illustrates one way in which the flow of information can be organised. The computer is thought of as a link between the planning department and the machine shop, translating planning information into machine priorities and also providing the planning department with the latest estimated delivery date of each final assembly.

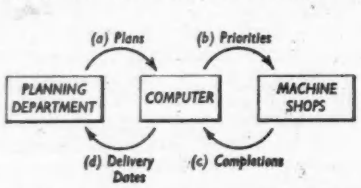

Fig. 2—Information flow for machine loading

It is an essential feature of this conception that the computer is thought of as an adviser to the machine shop, rather than as a director. The computed priorities should normally be adhered to, but there are going to be occasions when it is just not possible to do this because of machine breakdowns, absence of key personnel, supply difficulties and so forth. Moreover, the planning department's figures for the times that jobs should take are only estimates. For these reasons it is necessary that there should be a feed-back of information from the shops, to keep the computing process in line with the actual situation.

Information Handling.—There are thus four streams of information involved: two inputs to the computer and two outputs.

The contents of these streams are listed below together with estimates of the number of characters (i.e. letters or decimal digits) involved in each item.

Four Streams of Information to be Handled by Computer

	Number of characters
(*a*) Input from Planning Department.	
For each new final assembly :—	
(i) The time of acceptance of the order (day/hr/min)	7
(ii) The order number...	4
(iii) Penalty function parameters, say	20
	31
For each machine centre a list of new sub-orders giving :—	
(iv) Sub-order number...	7
(v) Order number of relevant final assembly... ...	4
(vi) Time required to complete sub-order (hr/min) ...	4
(vii) Lead time, i.e. the time by which the completion of the sub-order must be in advance of the completion of the final assembly if the latter is not to be delayed (day/hr/min)	7
(viii) Machine setting required	7
(ix) Sub-order number of previous operation, which must be complete before this sub-order can be completed	7
	36
(*b*) Output to Machine Shop.	
For each machine centre a list of sub-orders arranged in priority sequence giving :—	
(i) Sub-order number...	7
(ii) Estimate of time to complete sub-order	7
	14
(*c*) Input from Machine Shop.	
A list of sub-orders completed by each machine centre, giving :—	
(i) Sub-order number...	7
(ii) Time at which sub-order was completed	7
	14
(*d*) Output to Planning Department.	
A list of estimated completion dates of final assemblies, giving for each order :—	
(i) Order number of assembly	4
(ii) Estimated time when assembly will be completed	7
	11

A typical general machine shop which has been surveyed from this point of view has thirty machine groups, each processing on the average sixteen sub-orders a day (some more, some less). Again on the average, there are about thirty sub-orders in the queue for each machine centre at any time. There are about twenty final assemblies in the assembly shops at any time, and orders for these come in at the rate of about three per day.

On this basis the four streams of information listed above can be summarised as shown below. The volume of information involved is not large by comparison with commercial applications, and therefore cheap paper tape input and output equipment is adequate (rather than the expensive magnetic tape equipment usually required in commercial work). To allow the data to be readily printed on a page printer (to give an intelligible record of what has been input) some additional characters are needed (to give spaces, line feed, carriage return, &c.), and an allowance of 20 per cent has been added for these when calculating the figures shown.

Fig. 3—The "Pegasus" computer shown here has a main store of 4096 words

Summary of Information—Flow Characters/Day

	Input		Output
(*a*) Input from planning department	26,030	...	—
(*b*) Output to machine shop	—	...	10,080
(*c*) Input from machine shop	8,064	...	—
(*d*) Output to planning department...	—	...	264
	34,094	...	10,344

Using available paper tape equipment, the time for input and assembly of the input information listed above is about six minutes on "Pegasus." The time for punching the output information listed above on to paper tape is also about six minutes.

There will be some 34,000 characters a day to be punched by hand on to paper tape. This is within the daily capacity of one teleprinter operator (averaging 6000 characters an hour). In order to ensure the accuracy of the data it should be repunched by another operator, using the type of verifying equipment which is being marketed for this operation. In order to allow for sickness, overloading, &c., it would be as well to think in terms of three teleprinter operators for work on the scale described.

"Pegasus" Computer

The Ferranti "Pegasus" computer (Fig. 3), the machine the writer is most familiar with, has a store of about the right size for this kind of work. In the example quoted each item in a queue can be adequately represented by three "Pegasus" words. As there are thirty items in thirty queues, each represented

by three words, the computer storage required for the queues is about 2700 words. There is also a further requirement for storage of information relating to the due dates of final assemblies, and the penalties for delaying these final assemblies. For twenty assemblies three words each will suffice, bringing the total up to 2760. The main store of "Pegasus" holds 4096 words, so 1336 words are available for extension of the queues and for programme, which is a very adequate margin.

It will happen from time to time that the shops are overloaded and that all the storage space available in the computer is full. In this case the allocation of new sub-orders to queues will be held up until further completions are notified by the shops. This hold-up will not cause any embarrassment, as the shops will already have plenty to get on with under these conditions and there is, in fact, probably something to be said for withholding further sub-orders from the shops until the backlog is cleared.

If the shops are extended it would be best from every point of view to divide the larger production unit into two or more sub-units and process the data for each of these separately, with appropriate cross-referencing.

It is calculated that in most cases the time taken to scan a queue of thirty orders, evaluating each possible position in the queue and determining the minimum penalty position, will take about three seconds for each new sub-order or halt an hour a day for 600 sub-orders. Thus the total computer time for carrying out the daily procedure, including input computing and output, would be of the order of forty-two minutes on "Pegasus," or less than an hour a day for a general machine shop of the kind and size here considered.

Conclusion

The writer is convinced that there is a very urgent and important class of problems awaiting computer solution in the industrial field. Progress in this field has been slow so far because these problems are often inherently more difficult to analyse than many of those arising in purely scientific and in purely commercial work. One of the possible lines of attack has been indicated in this article. Real progress is beginning to be made now that the people faced with these problems are learning the computer's language and are beginning to programme their own problems. It is far easier for an experienced engineer to learn how to use a computer than it is for a specialist programmer to gain the operational experience on which a sound programme can be based. The methods proposed in this article only deal with one aspect of the field, and are put forward in the hope of stimulating a wider discussion of programming techniques for this type of work.

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[1] A Conference on Linear Programming, May, 1954, Ferranti, Ltd., Manchester, 1955.

[2] S. M. Johnson, "Optimal Two- and Three-Stage Production Schedules with Set-up Times Included," *Naval Logistics Research Quarterly*, March, 1954.

[3] R. Bellman and O. Gross, "Some Combinatorial Problems Arising in the Theory of Multi-Stage Processes," *Journal Soc. Ind. App. Math.*, September, 1954.

Motor Vessel "Essex Ferry"

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

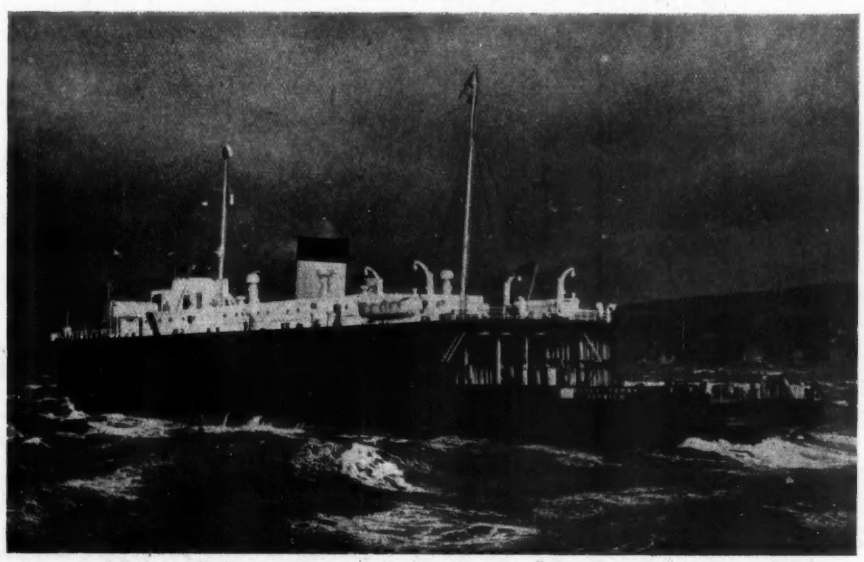
THE story of the train ferry is an interesting one, in that although the principle of carrying wagons from port to port to save the trans-shipment of their contents was recognised nearly 100 years ago, in 1860 to be precise, it took a major war to make the British realise the potentialities of the train ferry. In the year just alluded to, the North British Railway began to carry fully loaded railway wagons by boat across the Firth of Forth from Granton to Burntisland, and across the Tay from Newport to Dundee, but these ventures naturally ceased when the celebrated bridges were built, and the idea of a train ferry became moribund. Towards the middle of World War I the ports on both sides of the Channel were becoming hopelessly congested with munitions, locomotives and general warlike equipment very varied in character, and it was appreciated that a very great saving of time and cost would be effected if goods could be carried direct from the factory to the seat of war, and with commendable enterprise the British Government, with the agreement of France, decided to have built as a war measure three train ferries, and at the same time to construct an entirely new port at Richborough, Kent, which, incidentally, was never attacked by the Germans. From the latter part of 1917 these somewhat ungainly vessels did most useful work, while proving invaluable after the Armistice in bringing back to the country locomotives, guns and a variety of warlike stores.

The commercial history of the train ferry as far as this country is concerned began in 1924, when a private company acquired the three vessels, reconditioned them and inaugurated a regular service, restricted to goods only, between Harwich and Zeebrugge, a service which has since been regularly maintained, apart from war years. After ten years the service was taken over by the then London and North Eastern Railway. Unfortunately, World War II was responsible for the loss of two of the trio, but in 1946 train ferry No. 1, thoroughly overhauled and much improved in appearance, reopened the service, being given at the same time the name of "Essex Ferry." From the first it was obvious that one vessel could not maintain an adequate service, and next year the larger ship, "Suffolk Ferry," built specially for the service, joined her sister at Harwich. The new vessel was a motor ship, which proved so satisfactory, while traffic was increasing regularly, that a further vessel was justified, and early in 1951 "Norfolk Ferry" was launched at Clydebank at the yard of John Brown and Co., builders of "Suffolk Ferry," she being slightly larger and with modifications which were the result of experience. She proved a valuable addition to the fleet, which was now adequate to meet requirements. "Norfolk Ferry" has already been fully described in these pages.*

The original "Essex Ferry," veteran of two world wars, had had a strenuous life and it was decided that as soon as a new vessel could replace her the time had arrived for her to be, if not retired, at least put on the reserve list. An order was accordingly placed with John Brown and Co. (Clydebank), Ltd., for a vessel generally similar to "Norfolk Ferry," which had proved very satisfactory. The new vessel was launched on October 24 last, and underwent her trials on January 8 and 9, having had transferred to her the name "Essex Ferry." After these trials she was taken over by British Railways, and made the voyage of over 800 miles round Land's End to Harwich, where she arrived on January 12. On January 15, opportunity was afforded for a thorough inspection of the ship, while the methods of loading, &c., could be observed. "Essex Ferry" sailed on her maiden voyage from Harwich to Zeebrugge the same evening.

As will be seen from the illustration, the new vessel is similar to "Norfolk Ferry" in outline, her main mast giving her a more pleasing appearance than her sisters had when they began their lives, but since then both have had main masts added. The principal dimensions of the new vessel are: length between perpendiculars, 380ft; breadth moulded, 58ft 6in; depth moulded to upper deck, 35ft 6in; tonnage, 3242 gross, 1502 net; mean loaded draft, 12ft. Two Sulzer diesel engines drive the twin screws (each with a diameter of 9ft, a pitch of 9ft, and four blades) imparting a service speed of 13½ knots (maximum 14 knots). As will be noticed, the gross tonnage is rather larger than that of "Norfolk Ferry" (3157 tons)

* The Engineer, August 3, 1951, page 155



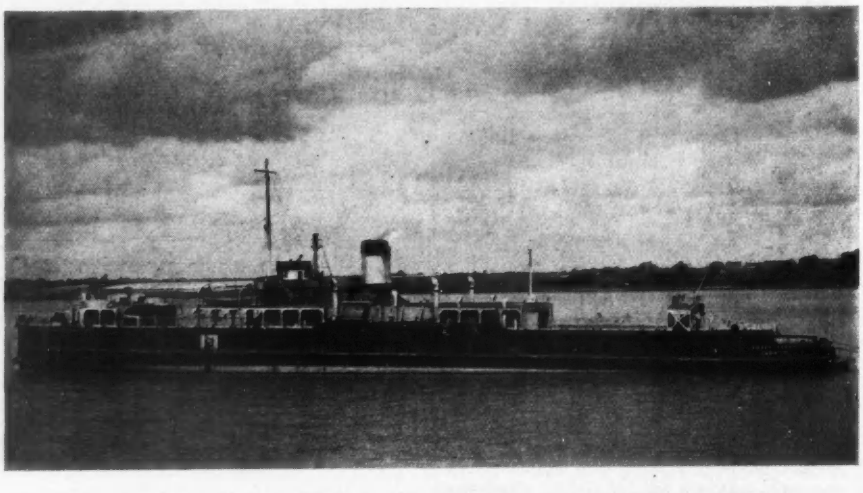
The "Essex Ferry" (3242 gross tons) on acceptance trials in the Clyde on January 8 and 9, 1957. The ferry can carry nearly forty international freight wagons and has accommodation for twelve passengers

In the case of "Essex Ferry," the auxiliary plant has been supplied by W. H. Allen, Sons and Co., Ltd., Bedford; there are three generators, each of 125kW, driven by Allen diesel engines with cylinders 9in by 12in, running at a speed of 620 r.p.m. As with her sister ship there are three Reavell air compressors, while steam for domestic purposes is supplied by an oil-fired Cochran boiler. An innovation in the new ship is the introduction of handling gear for railway containers.

As the arrangement of the four tracks, affording accommodation for thirty-six to thirty-eight international rail service wagons, is identical with that on "Norfolk Ferry," it is not proposed to describe it again, and, similarly, the engine-room layout is the same, as also are the aids to navigation, including echo sounder, decca navigator, radar and radio. There is accommodation in two-berth cabins for twelve passengers, the maximum allowed on a cargo vessel.

Mention should be made of the great improvement that has taken place in the Zeebrugge terminal since making our inaugural passage on "Norfolk Ferry." After a good crossing it was most exasperating to be kept waiting perhaps for an hour or two before being allowed to enter the lock which gave access to the ship canal and the ferry terminal. Lobbing about in a seaway was not a pleasant ending to a voyage for indifferent sailors, and it must be admitted that these train ferries have a tendency to roll, even though the motion is a steady one. In June, 1953, the new terminal in the outer harbour was opened, enabling the vessel to go direct to her berth, thereby saving considerable time in both directions. This ferry service permits a through service of goods wagons between Great Britain and all ports of the Continent apart from Spain and the U.S.S.R. At times it has been found that it has proved a difficult task to cope with requirements even when three ships have been operating, and some quick turns at both terminals have been effected.

For the sake of comparison a few particulars regarding the original "Essex Ferry" (Train Ferry No. 1) may be of interest. Her principal dimensions are: length, between perpendiculars, 350ft; breadth, moulded, 58ft 6in; depth, 17ft 3in; mean draught, 9ft 6in; tonnage, 2672 gross. She was provided with two sets of triple-expansion steam engines with cylinders of 18in, 29in and 47in diameter, with a stroke of 27in, and with steam at 180 lb per square inch pressure a speed of 12 knots was maintained.



The original "Essex Ferry," now renamed "Essex Ferry II," off Parkeston Quay

Consideration of Weight Transfer on B-B Electric Locomotives

By E. H. CROFT, A.M.I.C.E., M.I.E.E.*

In an electrical locomotive the design of the mechanical parts determines the amount of weight transfer per axle and the extent to which this transfer may reduce the true adhesive weight of the locomotive. Provided that the true adhesion can be increased, lighter locomotives can be used to haul a given load. The influence of mechanical design on weight transfer, adhesion and useful tractive effort is briefly discussed here.

THE load hauled by an electrically-driven locomotive is more often determined by its maximum tractive effort than by its continuously-rated tractive effort. This is because the load is often limited by a short-rated maximum service condition, such as a start on a gradient. The continuously rated tractive effort is dependent on the design of the electrical equipment, whereas the maximum depends mainly on the method of control and the design of the mechanical parts. Multi-notch control, which allows the mean notching current almost to equal the peak notching current, is an example of a means of control for obtaining maximum possible adhesion.

The design of mechanical parts determines the amount of weight transfer per axle or the degree to which this transfer is effective in reducing the true adhesive weight of the locomotive. If the true or effective adhesion can be increased, then smaller and lighter locomotives can haul the same trains, even to the extent of a B-B doing the work of a C-C. This brief article is limited to the considerations of mechanical design.

Principles of Design

A B-B locomotive of the following general data will be considered.

Total weight	80 tons
Axle load	20 tons
Bogie wheelbase	10ft
Wheel diameter	4ft
Drawgear height	3·5ft
Kingpin distance	20ft

In the first case the bogie thrust point will be assumed at drawgear height, no longitudinal bearers between body and bogie frame will be considered, and if articulation between bogies exists it will be assumed at drawgear height. Such an example is generally representative of older designs. It should be noted that in this case it makes no difference whether motors are axle hung or mounted on the bogie frame.

Let Z be the total tractive effort and W the weight transfer, then $W=(Z/2)\times(3\frac{1}{2}/10)=0\cdot175.Z$, and the true or effective adhesive weight will be $(20-W)\times4$.

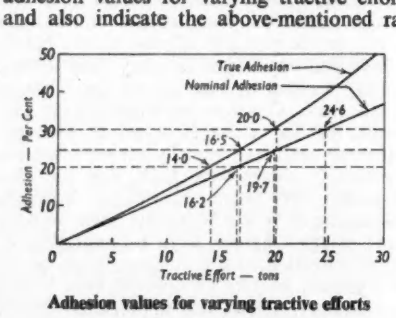
Table I shows the nominal or static and the true or effective adhesions corresponding to given values of tractive effort. Weight transfer and axle load are also shown. The seriousness of weight transfer in this case is obvious.

TABLE I

Tractive effort in tons	Nominal adhesion, per cent	Maximum negative weight transfer in tons	Minimum axle load in tons	True adhesion, per cent
5	6·25	0·875	19·125	6·54
10	12·5	1·75	18·25	13·7
15	18·75	2·625	17·375	21·6
20	25·0	3·5	16·5	30·3
25	31·25	4·375	15·625	40·0
30	37·5	5·25	14·75	50·8

One may assume 30 per cent adhesion is an approximate value of adhesion for a dry, clean rail, and 20 per cent for a wet rail for the slow speeds involved in moving a train under most service conditions. The load hauled, however, is mainly dependent on wet rail conditions with sand. Adhesion under these conditions varies but may be taken as 24 per cent approximately.

Curves on Fig. 1 show nominal and true adhesion values for varying tractive efforts and also indicate the above-mentioned rail adhesions. It is at once obvious that at 24 per cent adhesion, corresponding to a wet sanded rail, a 19 per cent increase in tractive effort is possible if the effects of weight transfer can be eliminated.



Adhesion values for varying tractive efforts

It has long been appreciated that by coupling the two axles of the bogie the effect of weight transfer may be eliminated, since the increase of load on the rear axle of the bogie may be equal to the decrease on the front axle if the bogie design is correct. At the present time much consideration is being given to axle coupling by means of gearing associated with the normal motor gearing. Such an arrangement seems to demand frame-borne motors, but this is no disadvantage since they are very desirable from the point of view of good riding and lighter track maintenance. Suitable designs of flexible drives are available. To obtain

* Traction Consultant to The General Electric Company, Ltd.

TABLE II

		Adhesion efficiency at 20 tons T.E.			
		Axles not coupled		Axles coupled	
		Kingpin distance 20ft	Kingpin distance 25ft	Kingpin distance 20ft	Kingpin distance 25ft
Axle-hung motors. Bogie thrust at drawgear height	No fore and aft bearers ...	Per cent (1) 82	Per cent (2) 82	Per cent (3) 100	Per cent (4) 100
	Fore and aft bearers*	(5) 85	(6) 86	(7) 97	(8) 98
Axle-hung motors. Bogie thrust at 2ft above rail level	No fore and aft bearers ...	(9) 86	(10) 87	(11) 96	(12) 97
	Fore and aft bearers*	(13) 85	(14) 86	(15) 97	(16) 98
Axle-hung motors. Bogie thrust at 1ft above rail level	No fore and aft bearers ...	(17) 89	(18) 90	(19) 94	(20) 95
	Fore and aft bearers*	(21) 85	(22) 86	(23) 97	(24) 98
Frame-mounted motors	No fore and aft bearers. Axles not equalised. Bogie thrust at drawgear height	(25) 82	(26) 82	(27) 100	(28) 100
	Fore and aft bearers. Axles equalised*	(29) 91	(30) 93	(31) 91	(32) 93

* Axles side equalised. Assumed that side bearers are at kingpin distance.

the full benefits of coupled axles (namely, true adhesion equal to nominal) it is essential that the bogie thrust point be at drawgear height, and that no fore and aft bearers be provided. If these two requirements are not complied with, weight transfer moments will be transferred to the body and result in loading the rear bogie and unloading the front.

Since axle-hung motors may still be used for some services, and since spring-borne axle-hung motors are receiving much attention, it is essential to consider how weight transfer can be reduced in the case of the axle-hung motor where no axle coupling is provided.

In Table II several alternatives are shown. In all cases a tractive effort of 20 tons is taken. The figure of adhesion efficiency is shown in each case. This is a useful figure for comparison and represents the effective adhesive weight, expressed as a percentage of the total weight, at a tractive effort of 25 per cent of the total locomotive weight, i.e. at 20 tons.

The calculations of the weight transfer from which the adhesion efficiency is obtained are simple. The following points, however, should be borne in mind.

The unsprung axle component of weight transfer, which is dependent on wheel radius and motor mounting base, in this case 4ft, cannot be transmitted to the body by the introduction of fore and aft bearers. In the locomotive considered this value is $(20/4)\times(2/4)=2\cdot5$ tons, being negative on the leading axle of each bogie and positive on each trailing axle. The reaction at the nose, namely, the sprung axle component, will be carried to the body, where fore and aft bearers are used. Where none are provided, it reduces the value of the unsprung component. Where motors are frame-mounted there are no unsprung components. All are either carried by the bogie frame or the body.

If fore and aft bearers be provided all bogie frame components must become body components and the height of the bogie thrust point is of no consequence whatever. So far as weight transfer is concerned, bogie frames and body function as one unit.

If no fore and aft bearers are provided the body component depends entirely on the height of the drawgear above the bogie thrust point.

The total body component causes a reduction of weight on the leading bogie and an increase of weight on the trailing; thus, where both bogie and body components exist, the weight transfer on all axles will not be equal, and the maximum negative value is the one upon which adhesion efficiency must be based.

In all cases where fore and aft bearers are provided, the axles should be equalised as, otherwise, sprung load would not be divided between the axles, and to obtain minimum weight transfer the axles should share equally the sprung body components.

CONCLUSIONS

(1) The effective adhesion of a typical B-B locomotive may vary between 82 per cent and 100 per cent, at a tractive effort of 25 per cent total locomotive weight, depending on the mechanical design (Table II).

(2) Only by the use of coupled axles can 100 per cent be obtained. This applies to axle-hung or frame-mounted motors (Table II).

(3) By adopting frame-mounted motors 90 per cent or more may be obtained (Table II). With axle-hung motors the value may be approximated by a low bogie thrust point (Table II).

(4) The greater the kingpin distance the higher the efficiency in most cases.

(5) Where 50 c/s alternating current is adopted for the overhead line, part of the transforming equipment is carried on the powered vehicle, which tends to be heavier, more costly and complex. Thus, the very best possible mechanical and control design is essential to obtain maximum tractive effort, and consequently greatest train weight.

Higher Technological Education

THE London and Home Counties Regional Advisory Council for Higher Technological Education has published its eighth annual report. It reviews the Council's work in the year ended August 31, 1956. As an example of the influence of the policy outlined in the White Paper on Technical Education, the report makes special reference to the "phenomenal growth of interest" in high-level sandwich courses. In 1955–56, it is stated, sandwich diploma courses were operating in seven colleges in the region. In the later months of the year, however, the Council's support was sought by local education authorities and governing bodies for courses of this kind, each of four or five years' duration, to operate in 1956–57 in about twenty colleges. This, the report observes, is "a phenomenal increase which has no parallel in the recent history of technical education." The sandwich courses now in operation or proposed cover civil engineering, mechanical engineering, electrical engineering, aeronautical engineering, production engineering, and chemical engineering, and other subjects, such as physics, applied chemistry, mathematics and building. The engineering group, the report adds, is represented by a total of about forty proposals, including courses already in operation. One of the Advisory Council's duties is to ensure, so far as practicable, that the provision of higher technological education in part-time and sandwich courses keeps in step with the ability of industry to supply a regular flow of students. The Council also endeavours to see to it that courses, where developed, meet genuine industrial needs, continue year by year with adequate numbers, and "do not prejudice the fortunes of other established courses."

200MW Turbo-Generators for Willington "B" Power Station

As announced briefly in January 18 issue, page 116, Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, is to supply two 200MW turbo-generators and associated equipment for Willington "B" power station, near Derby. The plant is due to be commissioned in 1961 and the order is worth £3,000,000.

An interesting innovation will be the use of direct water-cooling for the stator winding. It may be recalled that the first large generator to incorporate this method of cooling was a Metropolitan-Vickers 30MW machine which was commissioned recently in the Central Electricity Authority's Bold (St. Helens) power station. The system of direct water-cooling of the stator winding was described in our issue dated December 14, 1956, page 854. Rotor cooling will be by hydrogen circulated at a pressure of 30 lb per square inch, in a closed-circuit ventilation system, with standard Metropolitan-Vickers coolers arranged longitudinally in the annular space between the core and the stator frame.

Each generator, rated at 200MW, 0·8 p.f., 16·5kV, 50 c/s, at 3000 r.p.m., will be direct-coupled to a steam turbine designed for initial steam conditions of 2350 lb per square inch gauge at 1050 deg. Fah., with reheat at 1000 deg. Fah.; they will be the largest single-axis turbines built by the Metropolitan-Vickers Electrical Company, Ltd. The machines will be tested complete at the manufacturer's works but, to facilitate transport, the core and windings will be built on a skeleton frame which will be removed after the works tests and will be replaced on site.

An instructive comparison can be made between the Willington "B" generating sets and those at Battersea "A" to illustrate the reduction in overall size which is attributable to design developments, including improved cooling methods, over a period of twenty years or so. Each 200MW turbo-generator set for Willington "B" will be 20ft less in overall length than the 105MW at Battersea "A."

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—On January 25, R. E. Clements, B.Sc., read a paper entitled "A Method of Analysing Voyage Data" before the North East Coast Institution of Engineers and Shipbuilders. The paper describes a method of analysing service performance data, devised at the British Shipbuilding Research Association, by means of which it is possible to estimate the effect of weather and deterioration of the hull and propeller surface on the shaft horsepower necessary to maintain a given speed. A method of multiple-regression analysis is used to obtain the separate effects of adverse weather, and of fouling. It is shown how a suitable weather scale has been evolved by which it is possible to estimate the performance of a vessel in unrestricted waters, knowing only the wind strength and direction. A method of estimating propeller efficiency in service is also described, and it is shown how this can be used to estimate the efficiency under most conditions likely to be encountered in service. It is stated that by extending the analysis it is possible to estimate the thrust necessary to maintain a given speed under any conditions of weather or fouling. The paper restricts thrust analysis to comparisons between the thrust for a given speed in trial and the thrust for the same speed at the start of the maiden voyage and immediately after each subsequent dry-docking.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents.)

COMMITTEES

SIR,—May I add to your Leader of January 11 ? Service on committees is useful in discovering one's own errors. I often go to a committee meeting with my mind made up on some subject on the agenda, or hoping to be commended for some bit of work which I have done for the committee, only to learn that my ideas are only partially right or that the bit of work is less good than I had supposed. Many scientists and technical specialists are irritable and ineffective in committee, not so much because they cannot put their ideas into everyday language as because questions arise which are of a different sort from those with which they are familiar, and they don't know the answers. This situation is like that which may arise after a good dinner ; bring a materialist and an idealist together and one or the other will become irritated because his opponent raises questions which are off his own mind-track. Similarly, sometimes with the specialists in a committee meeting.

As a corollary, when a committee is charged with responsibility for coming to a decision, all-important and relevant points of view should be represented. For instance, it has been a good convention in Britain that, before going to war, both the Government and the Opposition should be in agreement. B.S.I. rightly works on the same principle in bringing manufacturers and users of engineering equipment together to produce standards. A problem which arises from this necessity to ensure representation of all-important viewpoints is the other necessity to keep committees small. Slowness in committee work is mostly attributable to attempts to do creative work in meetings or to setting a committee a task before the necessary constructive work has been done. Creative work can only be done by individuals or by teams of like-minded people. The useful functions of a committee are : (*a*) to criticise the creative work of individuals and to suggest alterations ; (*b*) to reach agreed decisions and give approvals, or positively to defer decision when there is insufficient reason for coming to a conclusion ; and (*c*) to establish that decisions have been agreed by the parties concerned.

The deriding of committees is justified when slow progress is attributable to the committees' straying outside these functions. It is not justified when a committee decides that there is insufficient reason for coming to a conclusion. A case in point is the B.S.I. committee which some years ago reported that it was impossible to produce a standard for non-sparking tools because of lack of sufficient knowledge of the sparking properties of different materials. The record of that committee's work is a good example of valuable, though negative, results.

Finally, the work of neither Isaiah nor St. Paul would be so good if it had not passed through various committees.

O. R. TUCKER
(Standards Engineer,
Courtaulds, Ltd.)

Braunston,
Near Rugby,
January 16, 1957.

THE AIR SPEED RECORD

SIR,—In your two issues of January 4 and January 11 you have looked back at the past year—and have found it, in many ways, uneventful. You state that " There was little that was dramatic and only an event here and there sufficient to startle the imagination into activity." The article on page 16, " Aeronautics in 1956, No. I " (under " Supersonic Flight "), states that " It is now possible to study, at least superficially, a large number of supersonic aircraft, fighters, and even bombers," and then proceeds to dilate upon six different types of American aircraft and two of French origin.

May I remind you of a happening on March 10, 1956, which, I suggest, " startled the imagination " of millions of British people and confounded the imagination of every other country in the world—this being the achievement of the Fairey " Delta " aircraft piloted by Peter Twiss. On this historic day—which your " Retrospect " so strangely omits—a British pilot in a British aircraft powered by a British engine, raised the world air speed record to 1132 m.p.h.—an increase of 308 m.p.h. over the then existing record. The fact that ten months after this event took place the Fairey " Delta " still holds the world record for speed in the air is one which surely merits mention, for world speed records are both difficult to obtain and even more difficult to retain.

I am well aware that it is in no way your policy to minimise British achievements and this makes it more difficult for me to understand how it is possible, in such a series of articles, to omit a British achievement of such importance.

C. H. CHICHESTER SMITH,
Director.

Fairey Aviation Company, Ltd.,
Hayes, Middlesex,
January 16, 1957.

NATIONAL LENDING LIBRARY FOR SCIENCE AND TECHNOLOGY

SIR,—Dr. Urquhart raises many fascinating problems for the future generation, not the least being to decide what will be useful amongst the millions of publications he prophesies ! In his last paragraph he points to the need to encourage scientists to study the flow of literature, and find satisfactory techniques for making it used. This is a sound proposition, but why not also start at first principles and ensure that all schools and colleges possess adequate libraries. In the training of the budding scientist and technologist why not see that he knows how to find out for himself, rather than solely train his memory to remember a lecturer's notes. At present, within the field of technical education this is not possible, as so few colleges even possess a library. As for attracting suitable staff, the reason may be more mundane than that proposed by Dr. Urquhart. In technical colleges the salary generally offered for a librarian is £200–£300 less than the lowest paid teacher.

GORDON H. WRIGHT

Hatfield, Herts,
January 21, 1957.

Literature

Automation in Theory and Practice. By E. M. HUGH-JONES. Basil Blackwell, 49, Broad Street, Oxford. Price 12s. 6d.

THIS book is a report of a course of seven lectures organised by Mr. E. M. Hugh-Jones, M.A., Fellow of Keble College, Oxford, and a lecturer in economics. The lectures were delivered to an undergraduate audience and they can be recommended, not only to students, but to all those who wish to obtain a general outline of automation and its possible impacts on economic and social life.

The introductory lecture is by Lord Halsbury. He divides automation into four independent components : (*a*) transfer machining, (*b*) automatic assembling, (*c*) communication engineering, (*d*) control engineering. He dismisses transfer machining in two brief paragraphs, but mentions that the first automatic transfer machines were built for Morris Motors in the early 1920s. The automatic assembly method is lightly touched on and the problems indicated. In the section devoted to communication engineering it is pointed out that " the important feature to understand is the divorce of signal from power," also that in automation the computer " must be thought of, not as a mathematical device, but rather as a coupling device, coupling groups of signals together : complex pattern of input to complex pattern of output." Control engineering is dealt with at greater length and the instability of control systems discussed ; with the summing up " There is accordingly no satisfactory mathematical theory of real control systems. In the absence of such a theory they are extraordinarily difficult to design." On electronics the lecturer points out the advantages to be obtained both from the flexibility in design and the simplicity in fabrication. " Electronic assemblies can be mass produced more cheaply than their mechanical counterparts " is one of his conclusions. Lord Halsbury also touches on the sociological aspects of automation. He gives good reasons, supported mathematically, for saying that unemployment due to automation need not be feared, but adds that employment not subject to automation will be the greater problem.

The second lecture, entitled " The Scientific Basis," is by R. H. Macmillan. He begins by saying that " technical processes whose possibility has been well known for years are now becoming financially feasible owing to the appearance of mass markets and the great shortage of labour," which has become very expensive. Moreover, processes which were formerly only theoretical possibilities can

now be applied in practice. Examples, simple and not so simple, are given of control and feedback systems, together with methods of dealing with the instability of control systems. The human operator is considered as a component in a closed loop system. Problems of making measurements on material in process when high standards of accuracy are required are discussed, and the value of the computer to those who are obliged to work on the batch method is considered. The lecturer has something to say about cybernetics in the field of physiology and mentions that the fluctuating population of rabbits versus lynxes in Canada is an example of the feedback process. He also quotes examples of feedback in the economic system.

Frank Woollard, in his contribution on "Automation in Engineering Production," claims that automation is evolution and not revolution, since it is a logical extension of the principles of flow production. What is new in automation is the extension of the automatic principle from the process industries to the manufacture of discrete units—those hard, heavy, awkward, unyielding shapes which must be machined to size within close tolerances. He thinks complete automation unlikely in any but the process industries, but says that there are complete automatic departments and that the Austin Motor Company has a semi-automatic assembly plant for motor cars. Automatic transfer machines were first conceived at the engine factory of Morris Motors, but the first automatic assembly plant was built by the A. O. Smith Company, of Milwaukee, for making automobile frames, the production being 10,000 frames, daily, in three eight-hour shifts. This lecturer stresses that the automation engineer aims to design his plant in such fashion that once the raw material is fed to the machine it will never touch the floor again, nor will it halt in its progress towards becoming the finished article. This involves not only transfer machines, but also linking devices between transfer machines. Inspection is an interruption to the flow, so that much attention is being paid to automatic gauging. Tool changing is partly mechanised by the use of control stations and tool-o-meters, operated by the cycling of the machine, warn operators when to change tools. With live banks of components between machines, the down time for tool changing has been reduced to the low figure of 5 per cent of total operating time. The lecture ends with a statement of the economies that can be achieved by automation.

The fourth lecture, by H. R. Nicholas, National Secretary, Metal and Engineering Group, of the Transport and General Workers' Union, deals with "The Trade Union Approach to Automation." Mr. Nicholas has forward looking views. He says: "The world needs the plenty that can be produced and the need will remain in our lifetime," and continues, "I will repeat that, without the technological advances of the past, and the forward strides now being made, we would be out of the running." The lecturer calls for more consultation between employers and employed when changes are contemplated and gives proof of its value. He calls also for fresh thinking about the avoidance of disputes, a fresh approach to the problem of grading workpeople, and fresh thinking about the wages structure. (Will not a reappraisal of the wage structure, based on job evaluation, be made inevitable by the growth of automation?) He also says: "The unions themselves will have to examine, closely, their own structures." He envisages a new approach to technical education and to training by employers in the new skills. Possible redundancy is discussed, but not assumed to be a necessary concomitant of automation. The lecturer poses the question as to what will happen to men whose work cannot be automated. Will it be possible to maintain a reasonable balance of hours and wages for them? The points raised do not arise solely from automation; they are matters which would have to be met in connection with any considerable technological advance. As he says: "The problems of the trade unions are the problems of industry and the nation. If we have the will we can find the means to resolve them together."

"Administrative Applications of Automation" is the subject of the fifth lecture by Mr. Spencer, who deals with the matter under such headings as "The Meaning of Administration," "Service and Routine Work," "Control of Information," "Research and General Management." To help students to appreciate the office functions he provides an appendix listing the work of an administrative office. Office machines are discussed and a brief description of punched card machines is given, and a section is devoted to the development and operation of computers. A second appendix provides a simplified description of a computer. An account of the work done by LEO—Lyons Electronic Office—is included. The value of the computer for producing vital statistics for management before they "go cold" is discussed, and also such items as technical calculations, market research and production planning. Sound advice about the dangers of launching into considerable expenditure on computers in order to be in the fashion are given.

"Social Aspects of Automation" is by Michael Argyle, a lecturer in social psychology. This lecture could apply to any factory whether automated or not. This is an indication that automation is not quite so special as some would have us believe. In speaking of workers' participation in discussing changes the lecturer says: "When I have discussed this with managers they say: 'What if our suggestion for change is turned down?'" Argyle gives the best possible advice: "Perhaps the solution to this is to allow participation only in discussion of methods and details of change. The decision to make the change has to be left to the management." The lecturer sees difficulty in placing operations men on an incentive system. Obviously piecework is ruled out on machines that are preset for feeds and speeds. The lecturer suggests that "some kind of merit rating" would meet the case. Possibly he has in mind a salary with bonus for running the machine without undue stoppages for tool changes or other interruptions.

Mr. E. M. Hugh-Jones provides the final lecture entitled "Automation To-day." It is in the nature of a general review—discursive, philosophical, speculative and witty. He attempts no definition, but sees automation "as a system of mechanical control, differing from earlier systems in the totality of its operations, the speed of its operations and the continuity of its operations." Many queries are raised in this lecture, some much to the point, while others emphasise that it is so easy to see "ghosts" in automation which, with actual contact, will vanish into the thin air.

There is a useful bibliography of further reading and a satisfactory index. The student will have a much better appreciation of the scope and character of automation after he has studied this little book.

Engineering Dynamics. Vol. II: Elastic Problems of Single Machine Elements. By C. B. BIEZENO and R. GRAMMEL. Translated from the German by M. L. Meyer. Blackie and Sons, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 90s.

TEXTBOOKS on strength of materials and theory of elasticity form an essential part of the reading of most engineers. The problems dealt with, however, are often academic rather than practical and selected with a view to illustrating the theory being studied rather than for their engineering importance. More advanced treatises often deal in great detail with only one class of problem.

In the second volume of *Engineering Dynamics*, the problems are selected with a practical bias, mainly from the field of mechanical engineering. The first volume covered the theory of elasticity; the third and fourth volumes are to deal with stresses and vibrations in steam turbines and internal combustion engines. The book is intended for advanced reading and assumes a considerable previous knowledge of the subject. In the chapters on beams, for example, the work starts with beams on three rigid supports, supposing the reader to be familiar with the simpler problems. Succeeding chapters analyse beams on elastic supports and continuous foundations. In discussing shafts, some time is spent dealing with the effect of holes, keyways and fillets. A second section describes ring problems such as the piston ring, helical springs, complete ring on several supports and the spoked wheel. The third section of the book analyses the stretching and bending of certain plates and shells, and the fourth section examines the elastic stability of the same beam, shaft, ring, plate and shell problems. The use of actual problems—for example, a cover plate with stiffening ribs or a four-spoked wheel—naturally leads at times to complicated mathematics and lengthy computations. It cannot, therefore, be expected that specific formulæ applicable to a particular problem will always be found, but rather a discussion of the methods available for certain classes of problems with some detailed solutions by way of illustration.

No attempt is made to discuss the mechanical properties of materials, but this volume alone provides a very useful collection of problems not often found under one cover, and, with the later volumes following in the same vein, the whole work represents a near monumental labour to the English version of which the translator will have subscribed no small part. The English script reads smoothly with no trace of the slightly out-of-place technical term which sometimes mars a translated work. The only pity is that nearly all the references given are to German or Dutch works, but even this has the compensating advantage of bringing to the reader's attention otherwise perhaps unknown papers.

Books Received

Rules and Regulations for the Construction and Classification of Steel Ships, 1956. Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3. Price 42s.

Records and Research in Engineering and Industrial Science. Third edition. By J. Edwin Holmstrom. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 60s.

Theory of Machines Through Worked Examples. Second edition. By G. H. Ryder. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 20s.

Scientific Research in British Universities, 1955-56. Published by Department of Scientific and Industrial Research. Obtainable from H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 21s.

Symposium on the Transatlantic Telephone Cable

A symposium on the transatlantic telephone cable was held on Thursday, January 24 at a joint meeting of the Institution of Electrical Engineers in London, the American Institute of Electrical Engineers in New York, and the Engineering Institute of Canada in Montreal. For forty-five minutes, from 7 p.m. (G.M.T.) these three institutions were linked by the telephone cable and the proceedings were conducted simultaneously, under the chairmanship of Sir Gordon Radley, president of the Institution of Electrical Engineers. Brief résumés of the papers comprising the symposium were given over the cable link by the authors, speaking either from London, Montreal or New York. Abstracts from three of the papers, dealing with the overall planning and design of the system, are reproduced below.*

Planning and Overall Performance[1]

THE transatlantic telephone cable system was planned primarily to connect London to New York and London to Montreal, and thus serve as an interconnection between continent-wide networks on the two sides of the Atlantic. The end sections of the system utilise facilities which are integral parts of the internal networks of the United States, Great Britain and Canada, but the essential new connecting links, extending between Oban, Scotland, and the United States-Canada border, and forming the greater part of the system, were built under an agreement between the joint owners—the American Telephone and Telegraph Company and its subsidiary the Eastern Telephone and Telegraph Company (operating in Canada), the British Post Office, and the Canadian Overseas Telecommunication Corporation. It is thus the joint effort of three nations.

In planning the system, the main centres of interest were, naturally, the two submarine cable sections, Scotland to Newfoundland, and Newfoundland to Nova Scotia, each of which had to meet a unique combination of requirements imposed by water depth, cable length and transmitted bandwidth.

Overall View of the System.—The transatlantic system provides twenty-nine telephone circuits between London and New York, six telephone circuits between London and Montreal, and a single circuit split between London-New York and London-Montreal; this split circuit is available for telegraph and other narrow-band uses. There are also twenty-four telephone circuits available for local service between Newfoundland and the mainland of Canada, and there is considerable excess capacity over the radio relay link that crosses the Maritime Provinces of Canada.

The overall lengths of the London to New York and London to Montreal circuits are 4078 and 4157 statute miles respectively. Seven of the New York to London circuits are permanently extended to European Continental centres—Paris, Frankfurt (two), Amsterdam, Brussels, Copenhagen and Berne. The longest circuit is thus New York to Copenhagen, 4948 miles.

Starting at London, which is the switching centre for United Kingdom and Continental points, twenty-four-circuit carrier cables provide two alternative routes to Glasgow and thence to Oban by a new coaxial cable. Between London and Oban the two routes are fed in parallel at the sending ends, so a changeover can be effected at the receiving ends only. At a later date an alternative route out of Oban will be provided by a new coaxial cable to Inverness.

From Oban a deep-sea submarine link[2] connects to Clarenville, Newfoundland. This link is in fact two parallel submarine cables, one used for east-to-west transmission, the other for transmission in the reverse direction. Each cable is roughly 1950 nautical miles in length and lies at depths varying between a few hundred fathoms on the Continental shelf and about 2300 fathoms at the deepest point. Each cable incorporates fifty-one repeaters in flexible housings, which compensate for the cable attenuation of about 3200 dB at the top frequency of 164 kc/s. These cables carry thirty-six telephone circuits plus maintenance circuits, and establish the present maximum capacity of the transatlantic system.

At Clarenville connection is made with Sydney Mines, Nova Scotia, by a second cable system,[3] which goes 63 statute miles overland to Terrenceville, Newfoundland, and thence about 270 nautical miles in coastal waters at a depth of about 250 fathoms. Although this system is partly on land, it is basically a submarine system in design, the two portions differing only in the protection of the cable. In this link the two directions of transmission are carried by the same cable, a low-frequency band being used from west to east and a high-frequency band in the opposite direction. In addition to the necessary maintenance circuits, a total of sixty two-way circuits is provided, thirty-six being used for transatlantic service, and the remainder being available for service between Newfoundland and the mainland. Sixteen two-way repeaters in rigid containers provide close to 1000 dB gain at this system's top frequency of 552 kc/s.

From Sydney Mines transmission is by radio relay to the United States-Canada border and thence to Portland, Maine; this system operates at about 4000 Mc/s and includes seventeen intermediate stations. From Portland, standard twelve-circuit carrier and coaxial cable facilities are used to connect with White Plains, New York, the American switching centre 30 miles north of New York City, where connection is made to the Bell system network.

The Montreal circuits leave the radio relay route at Spruce Lake, New Brunswick, a relay station near the border, from which point a short radio spur connects to St. John, New Brunswick, thence to Quebec on a twelve-circuit open-wire carrier system and thence to Montreal on a twelve-circuit cable carrier system.

British Background Experience.—In Great Britain, communication to the Continent dominated the early work in submarine telephony and led to systems providing relatively large numbers of circuits over short cables laid in shallow water. Early systems were unrepeatered, but the advantages of submerged repeaters were apparent. Experimental work, started in 1938, culminated in the first submerged repeater installation in an Anglesey-Isle of Man cable in 1943. Currently, there are many repeaters in the various shallow-water cables radiating from the British Isles.

These repeaters, although of a size and mechanical structure well suited to shallow-water applications, are not structurally suited to Atlantic depths. In 1948, the Post Office began to study deep-water problems, and the first laying tests of a deep-water repeater housing were conducted in the Bay of Biscay in 1951. This housing was rigid, like the shallow-water ones, but smaller and double ended so that the repeater was in line with the cable. Thus the rotation of the repeater, which accompanies the twisting and untwisting of the cable as tension is increased and decreased during the laying operation, could be tolerated. The housing now used by the British Post Office is basically the same as this early deep-water design, although minor modifications have been made to improve the closure and water seals.

A serious study of transatlantic telephony was begun by the Post Office in 1950, when a committee was set up to report on future possibilities of repeatered cables. As a result, it was decided in 1952 to engineer a new telephone cable to Scandinavia, 300 nautical miles in length, as a deep-water prototype, even though the requirements of depth, length and channel capacity could all have been met by existing shallow-water designs.

All the Post Office submarine systems are alike in that they use but a single cable, the "go" and "return" paths being carried by different frequency bands. The adoption of this plan was greatly influenced by the conditions under which the art developed. Because North Sea and Channel cables were highly subject to damage from fishing operations, it was desirable to limit the effects of such damage as much as possible. A single-cable system is obviously preferable under these circumstances to a system using separate "go" and "return" cables, which could be put out of service by damage to either cable. Since these systems were designed for shallow-water use, the additional container size required for two-way repeaters was of no great moment compared to the advantages of a single-cable system.

United States Background Experience.—In the United States, the cable art developed under very different circumstances. There was, of course, need for communication to Cuba, Catalina, Nantucket, and other offshore locations some of which involved conditions similar to those existing around the British Isles. The application of carrier to several of these cables occurred at an early date, but the repeater art was not directed at these shallow-water applications.

For many years, telephone communication to Europe had been an important goal and some thirty-five years ago a specific proposal was made by the Bell System to the Post Office for a single continuously loaded, non-repeatered cable to provide a single telephone circuit across the Atlantic.

This system was never built, partly because of the economic depression of the early 'thirties and partly because short-wave radio was able to meet current needs. Cable studies and experiments in the laboratory and field were continued, however, and largely influenced subsequent developments. It was at this time that the physical structure of the cable now used in the transatlantic system was worked out. It was also at this time that the harmful effects of physical irregularities in the cable were demonstrated. As cables are laid in deep water, high tensions are developed which unwrap the armour wires that normally spiral about the central structure. As tension changes during the laying process, twisting and untwisting which are harmless if distributed along the cable occur. But obstructions in the cable which prevent rotation, or any other process (such as starting and stopping of the ship) which tends to localise twisting, are likely to cause kinking of the cable and buckling of the conductors.

By 1932, electronic technology had advanced to a point where serious consideration could be given to a wideband system with numerous long-life repeaters laid on the bottom of the ocean and powered by current supplied over the cable from sources on shore.

The hazardous effects of obstructions in the cable, demonstrated in early laying tests, indicated that the chances of a successful deep-sea cable would be greatest if the repeaters were in small-diameter flexible housings which could pass through laying gear without stopping the ship and without restricting the normal untwisting and twisting of the cable. The structure ultimately evolved, consisting of two overlapping layers of abutting steel pressure rings within a flexible waterproof container, was an important influence on the electrical design, since it placed severe limitations on size and placement of individual components.

Because these repeaters were to lie without failure for many years on the ocean bottom, it was necessary either to provide a minimum number of components of the utmost reliability, or to provide duplicate components to take over in case of failure. The size limitation favoured the former approach. Similarly, the need for small size and minimum number of components militated against the use of two-way repeaters with their associated directional filters.

Out of these considerations grew the Bell

* The Symposium papers, which are listed in the references at the end of this article, will be republished this year in Vol. 104, Part B of the *Proceedings, I.E.E.*

System approach to solving the transatlantic problem by the use of two cables, each with built-in flexible amplifiers containing the minimum number of components of utmost reliability and a life objective of twenty years or better.

It was not until the end of the second world war that such a system could be tried. At this time it was decided to install a pair of cables on the Key West–Havana route to evaluate the transatlantic design which had evolved in the pre-war years. After further laying trials, this plan was completed in May, 1950, with the laying of two cables. Each of these had three built-in repeaters lying at depths down to 950 fathoms. These cables, each about 120 nautical miles in length, carry twenty-four telephone circuits. They have now been in continuous service for over six years without repeater failure or evidence of deterioration.

Early Transatlantic Technical Decisions.—Early in 1952, negotiations concerning a transatlantic cable were again opened between the American Telephone and Telegraph Company and the British Post Office. As indicated above, at that time each party had been laying plans for such a system. Thus it became necessary to evaluate the work on each side of the Atlantic to evolve the best technical solution.

It was found that the basic features of a deep-water design had been completed by the Bell System. Not only had many of the components been under laboratory test for many years, but a complete system had been operating for two and a half years between Havana and Key West. To use a phrase coined at the time, the design had proven integrity.

Because of the years of proof and the conservative approach adopted to assure long life, the design was far from modern. The thermionic valves, for example, had characteristics typical of those of the late 1930s, when, in fact, they were designed. Similarly, other components were essentially of pre-war design.

The Post Office, on the other hand, had pioneered shallow-water repeaters and were pre-eminent in this field. Their deep-water designs were still evolving and had not yet been subjected to the same rigorous tests as the Bell System repeaters. This later evolution, however, made possible a much more modern design. The thermionic valves, for example, had a mutual conductance of 6000 micromhos as compared with about 1000 in the Bell System repeater, and thus had a potentiality for much greater repeater bandwidths.

It was apparent from these reviews that only the American design was far enough advanced to assure service at an early date. It also appeared to have the integrity so essential to such a pioneering and costly effort as a transatlantic cable. On the other hand, the more modern Post Office design had many elements of potential value. If deep-water laying hazards could be overcome and proof of reliability established, it gave promise of greater flexibility and economy for future systems.

It was on these grounds that Dr. Mervin Kelly, for the Bell System, and Sir Gordon Radley, for the Post Office, jointly recommended that the Bell System design be used for the long length and great depths of the Atlantic crossing, and that the Post Office design be used for the Newfoundland–Nova Scotia link, where the shallower water afforded less hazard and better observation of this potentially interesting design. The decision to use the Post Office design was subject to technical review after deep-sea laying tests and further experience with circuits and components. This review, made in June, 1954, confirmed the soundness of the original recommendation.

Service Objectives.—It was agreed that the system should be designed as a connecting link between the North American and European long-distance networks. As such it should be capable of connecting any telephone in North America (ordinarily reached through the Bell System or Canadian long-distance networks) with any telephone in the British Isles or any 'phone normally reached from the British Isles through the European Continental network. The system would be designed primarily for message telephone service, but consideration would be given to the provision of other services, such as v.f. carrier telegraph, programme (music), and telephotograph as permitted by technical and contractual considerations. It was also agreed that the two submarine cable links should be so planned that it would be possible to utilise the full bandwidth in any desired manner in the future. Thus, for example, repeater test signals should be outside the main transmission band.

All elements in the submarine cable systems were to be planned for reliable service over a period of at least twenty years.

Transmission Objectives.—Since the transatlantic circuits were to connect two extensive networks, the broad objective was to add as little loss and other forms of impairment as practical. To this end, they were to be designed essentially to the standards of international circuits as defined by the C.C.I.F.† and of circuits connecting main switching points in national networks, as, for example, " regional centres " in the Bell System network and " zone centres " in the Post Office network.

The possibility of increasing the circuit capacity of the system by using channel spacings less than 4 kc/s was obvious. It was decided, however, to adopt, initially at least, the 4 kc/s spacing commonly used in long-distance systems on both sides of the Atlantic. This would make possible the use of standard multiplexing arrangements, and it was believed that the number of circuits provided would be adequate for the first few years of operation. It would undoubtedly be desirable to increase the number of circuits in later years, but a decision on the method to be used was left until completion of exploratory work on several methods which promised capacity increases with less degradation than narrow-band operation.

The decision to use standard terminal equipment led naturally to acceptance of the principle that the thirty-six circuits across the Atlantic would be assembled as three twelve-channel groups in the range 60 to 108 kc/s, and the sixty circuits between Newfoundland and Nova Scotia as five twelve-channel groups, and thence as a super-group in the range 312 to 552 kc/s. These are standard modulation stages in the multiplexing arrangements for broad-band carrier systems on both sides of the Atlantic. Two of the twelve-channel transatlantic groups would be connected to New York and the third would be split to provide six and a half circuits to Montreal and five and a half to New York in accordance with the agreement.

To provide for programme circuits, three eastbound and three westbound channels in each of the three transatlantic groups would be made available when required ; equipment would be provided to replace either two or three 4 kc/s message telephone channels by a programme channel. In order to avoid the agreed group pilot frequencies and to provide service to Montreal, it was agreed to utilise the frequency bands 68 to 76 kc/s or 64 to 76 kc/s in the twelve-channel groups for this purpose. Terminals of British Post Office design would be used at all points for translation between programme and carrier frequencies. The normal Bell System terminals could not be used, since they occupy the frequency ranges 80 to 88 kc/s and 76 to 88 kc/s, which are not compatible with the split-group arrangement or with the 84·08 kc/s end-to-end pilot.

System Design for North Atlantic Link[2]

Description of Link.—That portion of the transatlantic system which connects Newfoundland and Scotland consists of a physical four-wire, repeatered, undersea link, with appropriate terminal and power-feeding equipment in cable stations at Clarenville and at Oban.

Two separate coaxial cables connect Clarenville with Oban, one handling east-to-west transmission, the other west-to-east. Each is about 1940 nautical miles long. A total of 102 repeaters are installed in the two cables, at nominal intervals of 37·5 nautical miles. The cables also contain a number of simple undersea equalisers which are needed to bring system performance within the specified objectives.

The working spectrum of each cable extends from 20 to 164 kc/s, providing for thirty-six 4 kc/s message channels. Below this band are assigned the telephone (speaker) and telegraph (printer) circuits needed for maintenance and administration of the facility. Above the working band, between 167 and 174 kc/s, are the crystal frequencies which permit evaluation of the performance of each repeater individually from the shore stations.

The signal complex carried by the cables is derived in the carrier terminals from the signals on the individual voice-frequency circuits by conventional frequency-division techniques such as are employed in the Bell types J, K and L broadband carrier systems. These signals are applied to the cable through a transmitting amplifier which provides the necessary gain and protects the undersea repeaters from harmful overloads. At the incoming end of each cable, a receiving amplifier provides gain and permits level adjustment.

Shore equalisers, next to the transmitting and receiving amplifiers, insert fixed shapes for cable length and level compensation. Adjustable units provide for equalisation of the system against seasonal temperature changes on the ocean bed, and some ageing.

The power equipment[4] at each cable station includes : (*a*) regular primary power with diesel stand-by ; (*b*) rotary machines for driving the cable-current supplies, with battery stand-by ; (*c*) battery plants for supplying the carrier terminal bays, and last, but by no means least in complexity, (*d*) the cable-current supplies themselves. These latter furnish regulated direct current to a series loop consisting of the central conductors of the two cables, with their repeaters. A power-system earth is provided at the mid-point of the cable-current supply at each cable station.

Factors Affecting System Design.—Assurance of reliability dictated the use of elements whose integrity had been proved by successful prior experience. This resulted in the adoption of a coaxial-cable structure explored by the Bell Telephone Laboratories soon after the war, field tested in the Bahamas area in 1948, and applied commercially on the U.S. Air Force Missile Test Range project in 1953. It also resulted in the specification of a basic flexible repeater design which had been under test in the Laboratories since before the war, and had been in use on the Key West-Havana submarine-cable telephone system since 1950.

The cable adopted was the largest that had been successfully laid in deep water, and its size afforded an important benefit in the form of reduced unit attenuation. The structure and characteristics of this cable are covered in detail in a companion paper.[5] Suffice it to point out here that by its adoption for the North Atlantic link, there were specified for the system designers : (*a*) the attenuation characteristic of the transmission medium ; (*b*) the influence on this of the pressure and temperature environments ; (*c*) the unit contribution of the cable to the resistance of the power loop, and (*d*) the impedances faced by the repeaters.

The adaptation[6] of the basic Key West-Havana repeater design to the present project likewise presented the system designers with certain restrictions. Most important, the space and form of the long, tubular structure limited the size of the high-voltage capacitors in the power-separation filters, and thus their voltage rating, to such an extent that this determined the maximum permissible number of repeaters. Likewise, the performance of the repeater circuit was at least partially defined because of several factors. One was the effect of the physical shape on parasitic capacitances in the circuit, which in turn reacted on the feed-back and hence on intermodulation performance, and the gain/bandwidth and ageing characteristics. Use of the Key West-Havana thermionic valve influenced the above factors and also tended to fix the input noise figure and load capacity.

In similar respects, the principle of proven integrity reacted into the broad consideration of system design. For instance, in a long system having many repeaters in tandem, automatic gain control (gain regulation) in the repeaters provides an ideal method for minimising the amount of the total system margin which must be allocated to environmental loss variations. However, this would have required the adoption of elements of unproved integrity which might have increased

† The International Consultative Committee on Telephony (C.C.I.F.) bases its recommendations on a circuit 2500km (1600 miles) in length, with implied *pro rata* increases for noise impairment.

the probability of system failure. So the more simple and reliable alternative was adopted, i.e. fixed-gain repeaters with built-in system margins.

The inaccessibility of the undersea system for periodic or seasonal adjustment and the decision to avoid automatic gain regulation were major factors in the allocation of system margins between undersea and shore locations. To avoid wasting such a valuable commodity as margin required the most careful consideration of means of trimming the system during laying. Equalisation for control of misalignment in the undersea link is a function of the match between cable attenuation and repeater gain. Generally speaking, these are fixed at the factory. Very small unit deviations from gain and loss objectives could well add to an impressive total in a 3200 dB system. Accordingly, it was necessary to plan for periodic adjustment of cable length during laying and, where necessary, insertion of simple "mop-up" undersea equalisers at the adjustment points.

As in most transmission media, the attenuation of the cable increases with increasing frequency. Hence the greater the bandwidth of the system, the greater is the number of repeaters needed.

In this system, powered only from its ends, the maximum permissible number of repeaters and thus the repeater spacing is determined by a d.c. voltage limitation, as explained above.

With the repeater spacing fixed, and the type of cable fixed, the required repeater gain/frequency characteristic is known to the degree of accuracy that the cable attenuation is known. The frequency band that can be utilised, then, depends on repeater design considerations, including gain/bandwidth limitations, signal power capacity, and signal/noise requirements.

The early studies of the transatlantic system were based on "scaling-up" the Key West-Havana system. In these studies consideration was given to extending the band upward as far as possible by using compandors on the top channels, thus lightening the signal/noise requirements on these channels by some 15 dB, provided that they are restricted to message telephone service.

As the repeater design was worked out in detail, however, it became evident that a rather sharp upper frequency limit existed. This resulted from the parasitic capacitances imposed by the size and shape of the flexible repeater, the degree of precision required in matching repeater gain to cable loss in such a long system, and the feedback requirements as related to the requirement of at least twenty years' life.

These limitations resulted in the decision to develop a system with thirty-six channels of 4 kc/s carrier spacing, utilising the frequency band from 20 to 164 kc/s.

Acknowledgments.—The cable station at Clarenville was designed by United States architects from requirements furnished by American Telephone and Telegraph Company engineers and was approved by the other parties to the enterprise. The building was constructed by a Canadian firm under the supervision of a Canadian architect. The equipment was installed by the Northern Electric Company and tested by representatives of the Bell Telephone Laboratories, Eastern Telephone and Telegraph Company, Northern Electric Company and the British Post Office.

Cable for the undersea link was manufactured by Submarine Cables, Ltd., Erith, England, and the Simplex Wire and Cable Corporation, Newington, N.H., U.S.A. The repeaters[7] were made by the Western Electric Company, Hillside, N.J., U.S.A., and armoured by the Simplex Wire and Cable Corporation.

The cable station at Oban was built by British contractors from designs drawn up by the British Post Office. Its equipment was installed by a British electrical contracting firm. Two Western Electric Company installers were present at Oban during the installation of the American-made cable terminating equipment and of the cable current supply bays, to provide necessary liaison and interpretation of drawing requirements. The Oban equipment was tested by representatives of the British Post Office, the Bell Telephone Laboratories, and the contractors.

Newfoundland–Nova Scotia Link[3]

Route.—The choice of Clarenville as the junction point of the two submarine sections of the transatlantic system was determined primarily in relation to the Atlantic crossing and the desire to follow a transatlantic route to the north of existing telegraph cables.[8] There were a number of possibilities for the route between Clarenville and the east coast of Cape Breton Island, the most easterly point which could be reached reliably by the radio relay system through the Maritime Provinces of Canada. One possibility, which had been considered earlier, was to cross Newfoundland by a radio relay system and to employ a submarine cable link across Cabot Strait only. The final decision to build a cable system between Clarenville and Sydney Mines raised a number of problems in respect of the route to be followed, concerned primarily with potential hazards to the cable brought about by :

(*a*) The existence of very extensive trawling grounds on the Newfoundland Banks.

(*b*) The location of considerable numbers of telegraph cables in the vicinity.

(*c*) Grounding icebergs.

The route finally selected after thorough on-the-spot investigations is satisfactory in respect of all these hazards, involving no cable crossings and being inshore of the main fishing grounds. The total cable length is 326 n.m., of which 54·8 n.m. are between Clarenville and Terrenceville, Newfoundland, where the cable finally enters the sea. The maximum depth of water involved is about 260 fathoms.

Cable : Choice of Design.—Since 1930, when the Key West-Havana No. 4 cable was constructed, it has been usual to extrude the insulation of coaxial submarine cables to a diameter of about 0·62in, and most of the cables in the waters round the British Isles are of this size. The experience of the British Post Office with submerged repeaters in its home waters, dating from 1944, when the first repeater was laid between Anglesey and the Isle of Man, has therefore been mainly with 0·62in cables, first with paragutta as a dielectric and later with polyethylene. Most of these cables were originally operated without repeaters, and the sixty-circuit both-way repeaters which are now installed on the routes were designed to match their characteristics.

In planning a new system the size of cable will be determined by one of the following considerations :—

(i) Minimum annual charges for the desired number of circuits.

(ii) Terminal voltage required to feed the requisite number of repeaters.

(iii) Maximum number of repeaters or minimum repeater spacing which is considered permissible.

(iv) Maximum (or minimum) size of cable which can be safely handled by the laying gear in the cable ship.

When the thirty-six-circuit system between Aberdeen, Scotland, and Bergen, Norway, was planned in 1952 the route length (300 n.m.) greatly exceeded that of any other submarine telephone system, and it was decided to use a core diameter of 0·935in, first to keep the number of repeaters as low as seven ; and secondly, because the system was intended as a prototype of a possible Atlantic cable. The cable dielectric is polyethylene (Grade 2) with 5 per cent polyisobutylene.

The Oban-Clarenville link is designed to provide the maximum number of circuits on 0·62in diameter cable, and the limiting consideration is the terminal voltage required to energise the repeaters.

For the Clarenville-Sydney Mines link it proved possible to design for minimum annual charges. With increasing experience and confidence in submerged repeaters, it was no longer considered necessary to restrict the number of repeaters as for Aberdeen-Bergen, and the terminal voltage requirements were reasonable. At the current prices of cable and repeaters in Great Britain the optimum core diameter for sixty both-way circuits is about 0·55in, but the increased charge incurred by using 0·62in cable is less than 5 per cent (0·62in core is optimum for 120 both-way circuits). In order to facilitate manufacture and the provision of spare cable it was therefore logical to adopt the same design as that proposed for the Atlantic crossing and described elsewhere.[5]

After investigating various possible types of cable for the overland section in Newfoundland it was decided to use a design essentially the same as the main cable but with additional screening against external interference. As far as the outer conductor and its copper binding tape, the construction is identical with that of the main cable, except that the compounded cotton tape is overlapped. Outside this are five layers of soft iron tapes, each 0·006in thick, the innermost being longitudinal and the others having alternate right and left-hand lays at 45 deg. to the axis of the cable. After another layer of compounded cotton tape there is extruded a polyethylene sheath, 0·080in thick, and the whole is jute served and wire armoured. As a check on the efficiency of the screening, the maximum sheath transfer impedance at 20 and 100 kc/s was specified as 0·005 ohm per 1000 yards.

Make-Up of Cable from Centre Radially Outwards

Centre conductor, 0·1318in diameter copper
Three 0·0145in copper surround tapes
Polyethylene to 0·620in diameter.
Six 0·016in copper return tapes
0·003in overlapped copper teredo tape
Impregnated cotton tape
Five iron screen tapes
Impregnated cotton tape overlapped
Polyethylene sheath to 1·02in diameter
Inner serving of tarred jute yarn
Armour wire 29 × 0·128in diameter
Outer serving of tarred jute yarn

It was thus possible to treat the entire link from Clarenville to Sydney Mines as a uniform whole, using the same type of repeater on land as in the sea. A small hut at Terrenceville contains passive networks only.

Attenuation Characteristics.—When the system was designed, precision measurements of cable attenuation were not available. The design of the Oban-Clarenville link was based on laboratory measurements on earlier 0·62in cable of a similar type, but the available data applied only to frequencies up to about 180 kc/s, whereas the Clarenville-Sydney Mines link was to operate at frequencies up to 552 kc/s ; extensive extrapolation was therefore involved. As soon as the first production lengths of cable became available in February, 1955, laying trials were carried out off Gibraltar, and it was found that there were serious changes of attenuation on laying, over and above those directly attributable to temperature and pressure effects, and that the assumed characteristics were inaccurate. Although the attenuation in the factory tanks had been in reasonable agreement with that of the earlier cable, there were changes on transfer to the ship's tanks and again on laying, amounting in all to a reduction of about 1·5 per cent at 180 kc/s. This would have been comparatively unimportant had the discrepancy been of "cable shape," i.e. the same fraction of the cable attenuation at all frequencies and therefore exactly compensated by a length adjustment of the repeater sections. As this was not so, and as the cable-equalising networks in the repeaters were settled by this time, it was clear that precise information must be obtained in order that suitable additional equalisers could be provided for insertion in the cable on laying. There are a number of factors which can lead to small changes of attenuation on laying, but most of these tend to increase the losses. The primary reason for the observed changes appears to be contact variations between the various elements of the inner and outer conductors, i.e. the wire and three helical tapes forming the centre conductor and the six helical tapes forming the return conductor. These contact resistances tend to change with handling, and as a result of a slight degree of "bird caging" when coiled, it seems that the attenuation decreases as the coiling radius increases, and vice versa. Also, the effect of sea pressure is to consolidate the conductors and thereby further reduce the attenuation—an effect which appears to continue on a diminishing basis for a long time after laying.

To obtain reliable data for the Clarenville-Sydney Mines link, 10 n.m. of cable with "A"-type armour was laid at about the mean depth of the system (120 fathoms), off the Isle of Skye.

In making a final determination of the cutting lengths for the repeater sections, it was assumed that the factory measurements of attenuation would be reduced by 1·42 per cent at 552 kc/s on laying, that the temperature coefficient of attenuation would be +0·16 per cent per deg.

Cent., and that the true pressure coefficient of attenuation was negligible at the depths involved.

Circuit Provision and Frequency Allocation.—It was originally thought that a design similar to that of the Aberdeen-Bergen system would be suitable for the Clarenville-Sydney Mines route in that it would provide more circuits (thirty-six) than the long section across the Atlantic. This potential excess capacity, which was required for circuits between Newfoundland and the Canadian mainland, disappeared when it was found that thirty-six circuits could, in fact, be provided over the longer link. The Aberdeen-Bergen design was therefore modified to provide a complete supergroup of sixty circuits, the same capacity as the earlier British projects. The system thus requires broad-band transmission of 240 kc/s in each direction.

In the earlier British projects the frequency bands transmitted are 24–264 kc/s and 312–552 kc/s, but for the present purpose the lower band is dropped by 4 kc/s to 20–260 kc/s, so that the lowest frequency is the same as on the Atlantic cables. This enables common frequency-generating equipment to be used at Clarenville for the two links and minimises cross-talk problems.

Submerged Repeaters.—The submerged repeaters employed are fully described elsewhere,[9] and it will suffice to note here that they are rigid units, approximately cylindrical in shape, 9ft long and 10½in maximum diameter. They are capable of withstanding the full laying tension in deep water, although this is of little importance in the present application.

They are arranged for both-way transmission through a common amplifier which has two forward paths in parallel, with a single feed-back path. The two halves of the amplifier are so arranged that practically any component can fail in one, without affecting the other.

Power-Feeding Arrangements.—The submerged repeaters are energised by constant-current d.c. supplies between the centre conductor and earth, the power units at the two ends being in series aiding and the repeater power circuits being in series with the centre conductor, i.e. without earth connections. This is the only arrangement by which it is possible to control the supply accurately at every repeater, the insulation resistance of cable and repeaters being sufficiently great that the current in the centre conductor is virtually the same at all points. The constant-current feature of the supply ensures that repeaters cannot be over-run in the event of an earth fault on the system.

On the Oban-Clarenville link the anode voltage is derived from the drop across the valve heaters. This results in the heaters being at a positive potential with respect to the cathodes, a condition which tends to break down the heater-cathode insulation. In the American valves[10] this insulation is very robust and the risk is considered to be negligible, but in the current British valves, which have a much higher performance, the arrangement is undesirable. In view of the much smaller number of repeaters it was possible to derive the heater and anode supplies [as illustrated in the paper] and thus to reverse the sense of the heater-cathode voltage and also to provide an anode voltage of 90, against 55 in the longer link.

With this arrangement the link requires a total supply voltage of about 2300. The power-feeding equipment[11] at each terminal station is designed to feed a constant current of 316mA at this voltage, and it is permissible to energise the system from one end only, if necessary. The repeater capacitors—the limiting factors in respect of line voltage—are rated very conservatively at 2500V, so that a single-ended supply of 2300V, with the possibility of superimposed earth-potential differences, is near the desirable maximum. The two terminal power units are therefore designed to operate in series and to share the voltage.

With access to the cable provided at Terrenceville it is possible to operate the power system on the following bases :

(*a*) No earth at Terrenceville, power from both ends on a master-and-slave basis (to ensure that the constant-current units do not build up an excessive voltage) ; this is the normal arrangement.

(*b*) No earth at Terrenceville, power from one end only.

(*c*) Earth at Terrenceville, with the Clarenville and Sydney Mines power units energising the land and sea cables respectively ; this arrangement has been particularly useful during the installation period.

The presence of high voltages on the cable constitutes a potential danger to personnel, hence special precautions are taken in the design of the equipment in which the cable terminates and in which high voltages exist or may exist.

The earth connections for the power circuits at the two ends are via special earth cables and earth plates located about half a mile from the main cable, and metering arrangements are provided to check that the current does in fact take this path. These measures ensure that the current returning via the cable armour is never sufficient to cause serious corrosion.

Acknowledgments.—Post Office staff have been responsible for designs and for inspection and testing at home and in the field, as well as the laying of the submarine-cable system by H.M.T.S. "Monarch." In Great Britain, Submarine Cables, Ltd., and the Southern United Telephone Company, Ltd., provided the submarine and overland cables, respectively, while Standard Telephones and Cables, Ltd., supplied and contributed much to the design of the submerged repeaters and terminal equipment. On site, the assistance rendered by the Ordnance Survey of Great Britain, the Canadian Comstock Company, Ltd., who laid the cable across Newfoundland, the Northern Electric Company, Ltd., who carried out the terminal equipment installations, and by the other partners in the project, the American Telephone and Telegraph Company, Inc., the Canadian Overseas Telecommunication Corporation and the Eastern Telephone and Telegraph Company, has been invaluable.

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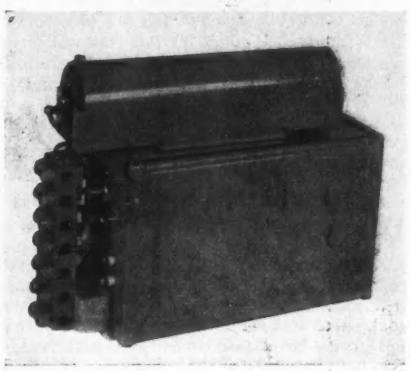
"Multiplexing" System for Remote Indication

A DIRECT-CURRENT "multiplexing" system for the continuous indication, at a central point, of the operating state of apparatus in remote locations, has been developed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. Information from up to twelve remote items of equipment can be relayed to the control point along a single pair of wires, whereas previously one pair of service wires would have been required for each unit to be monitored. Old installations can now be more extensively covered by using the existing cables to service a greater number of points. The equipment was originally designed for monitoring airfield control lights, but can be applied to many other kinds of installation, such as hydro-electric schemes or mines.

The equipment, which uses transistors, consists of up to twelve transmitter units and a cabinet containing the corresponding receiver sub-units. Each of the transmitter units (one of which is illustrated here) is an audio-frequency oscillator tuned to a different frequency. These units are distributed along the wires so that one is adjacent to each point to be monitored. Each receiver sub-unit consists of a band-pass filter, amplifier, detector and relay, each band-pass filter being tuned to a particular transmitter frequency.

Any operation of the equipment being monitored can be arranged to switch the adjacent monitoring transmitter. When a particular oscillator tone is present on the wires the relay in the corresponding receiver operates and, by a suitable circuit, can be used to show which transmitter is working. For example, the extinguishing of an essential warning light can be signalled by the disappearance of the associated oscillator tone from the receiver.

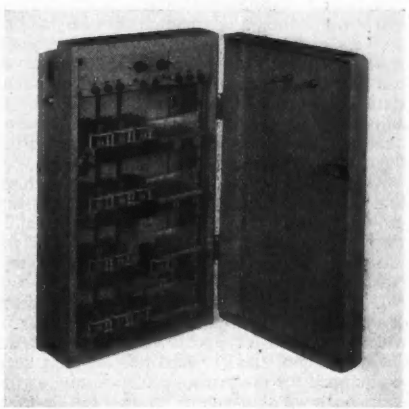
Each transmitter unit is enclosed in a hermetically-sealed can and connections are



The transmitter unit in the "Multiplex" remote indicating system is an audio-frequency oscillator tuned to a particular frequency

made to a terminal block. A case can be provided to house a dry battery, as illustrated. It is stated that, on continuous load, the battery will operate for approximately six months before replacement becomes necessary. If it is undesirable to use a battery the transmitter can operate from a d.c. supply of 50V.

The receiver cabinet illustrated here can house twelve working receiver sub-units and



Information from twelve transmitter units can be accepted by the receiver cabinet, which is shown with one of its twelve receiver sub-units partly withdrawn

twelve spare sub-units or, alternatively, twenty-four working receiver units for operation on two pairs of wires, giving a service to a maximum of twenty-four monitoring points. The band-pass filter and relay are in separate hermetically-sealed cans, and the detector and amplifier are cast in epoxy resin.

The equipment, which is designed to operate over a wide range of temperatures and humidity, can be used to relay signals along wires up to 5 miles in length.

COMMITTEE ON SYNTHETIC DETERGENTS.—The Ministry of Housing and Local Government has announced the membership of the standing technical committee on synthetic detergents. Mr. H. W. Cremer, M.I.Chem.E., a consulting chemical engineer, has agreed to serve as chairman. The committee is required to keep under review the difficulties arising in sewage works, rivers and water supply as a result of the use of synthetic detergents, and to encourage research into methods by which those difficulties could be avoided or overcome without an "undue burden on public funds."

Two Colliery Reorganisation Schemes

No. II—(*concluded from page 142, January 25*)

The recent publication of "British Coal; the Rebirth of an Industry," marked the completion of the first ten years of public ownership of the mines of this country. It is pointed out that under the 1950 plan it was proposed to remodel some 250 collieries and that work is in hand on no less than 180 projects. Two reorganisation projects which were in hand before the plan was produced are those at the Bradford colliery, Manchester and the Bold colliery, near St. Helens, Lancs. The first of these projects is in an advanced state and the second has just been completed. Some impression is given in this article of the great amount of work entailed in planning and carrying out such extensive reorganisation schemes.

Reorganisation of Bold Colliery

WHEN the scheme for the reorganisation of the Bold Colliery near St. Helens was prepared it was estimated that there were workable reserves of 61,000,000 tons of coal in the area. It was also considered that the output of saleable coal, which totalled under 200,000 tons a year in 1947, could be increased to 840,000 tons annually. The reorganisation of the colliery has now been completed and whilst this work was in progress the annual coal output steadily rose; in 1955 it totalled nearly 507,000 tons and is still increasing. Under the reorganisation scheme practically all the original surface building and plant have been replaced by modern structures and equipment; steam power has been replaced by electric drives, and a new coal preparation plant and a new station for compressed air supplies have been built. In designing the power and handling facilities full provision has been made for all structural and equipment requirements until the foreseeable end of the life of the colliery. An overall contract for carrying out the civil engineering work in connection with this project was placed with Simon-Carves, Ltd., and the work was divided up into a number of individual sections, each of which formed the subject of a separate tender. An important part of the scheme has been the construction of the new Bold power station by the Central Electricity Authority adjoining the site of the mine, and fuel is delivered directly by conveyors to this power station from the coal preparation plant of the mine.

Although an extensive underground reorganisation scheme has been an important part of this project, the following description deals mainly with the modernisation scheme carried out on the surface plant. Three shafts serve the colliery, Nos. 1 and 3 being each 915 yards deep and No. 2 some 600 yards deep. Under the scheme of underground reorganisation the No. 1 shaft, which was used for upcast ventilation and the development of the 915-yard horizon, has been re-equipped for downcast ventilation and as the main coal winding shaft. A new pit bottom circuit serving this shaft has been equipped with battery locomotive haulage and modern car loading and unloading equipment for the cages. The No. 2 shaft has been retained for coal winding, for servicing, and for downcast ventilation of the 600-yard level. It is served by the previously used endless rope haulage system. The No. 3 shaft, which is used for upcast ventilation, has been equipped for man riding and materials to the 915-yard horizon. A pair of steel arch-lined 15ft by 13ft tunnels, some 2000 yards long, have been driven underground for locomotive haulage and coal is taken by steel plate conveyors from the faces to tub loading stations built to serve the system. The conventional longwall advancing system of working has been retained in the mine and a pneumatic goaf stowing system is being introduced. For this purpose stowing dirt is brought in by 126 cubic feet capacity cars from the surface and emptied in a tipping station for distribution, the cars then pass into the coal loading system.

An impression of the considerable changes which have been made on the surface is given by the photographs reproduced in Figs. 6 and 7, one showing the original pit head-gear and the other the new structures. All of the original head-gears and winder houses have been replaced by concrete structures, and the organisation entailed can be appreciated when it is mentioned that the new head-gears were constructed over and around the old structures whilst they continued in operation. The complete reconstruction scheme, which was prepared for the surface of the mine in addition to the new winding equipment, involved the introduction of new ventilating plant, a compressor plant, a coal preparation plant, workshops and ancillary buildings. Ground conditions were not favourable for the construction of new buildings with heavy equipment, as the colliery is sited on a deep bed of peat, which necessitated the driving of piles through this peat bed to carry the foundations of practically every one of the new buildings and structures. Although the scheme was comprehensive the difficulties involved at the previously described Bradford colliery were not experienced in the same degree as there was plenty of room on the site and careful planning, using the three shafts, enabled the scheme to proceed and production to be increased as successive stages were completed.

Under the surface reorganisation scheme No. 1 shaft had to be re-equipped. This shaft was originally sunk in 1880 at a diameter of 12ft and to a depth of 404 yards. Later it was enlarged to a diameter of 21ft and deepened to 920 yards. It was brick lined and equipped with two-deck cages and operated by a steam-driven winding engine, which was old and in a poor condition. As already mentioned, it was decided to convert this shaft from upcast to downcast ventilation and use it for the main coal winding shaft.

The shaft has now been equipped with a ground-mounted Koepe winding gear and has two three-deck cages designed for handling two 1½-ton capacity mine cars on each deck. Its

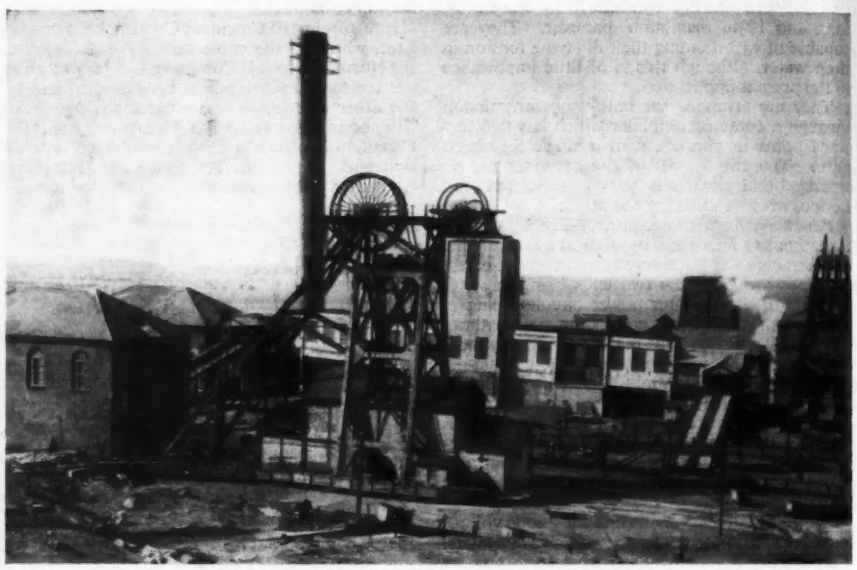


Fig. 6—Pit head installations at Bold colliery before reorganisation

Fig. 7—Pit head installation after reorganisation. The steam winding gear and steel head-gears have been replaced by electrically driven equipment and reinforced concrete structures

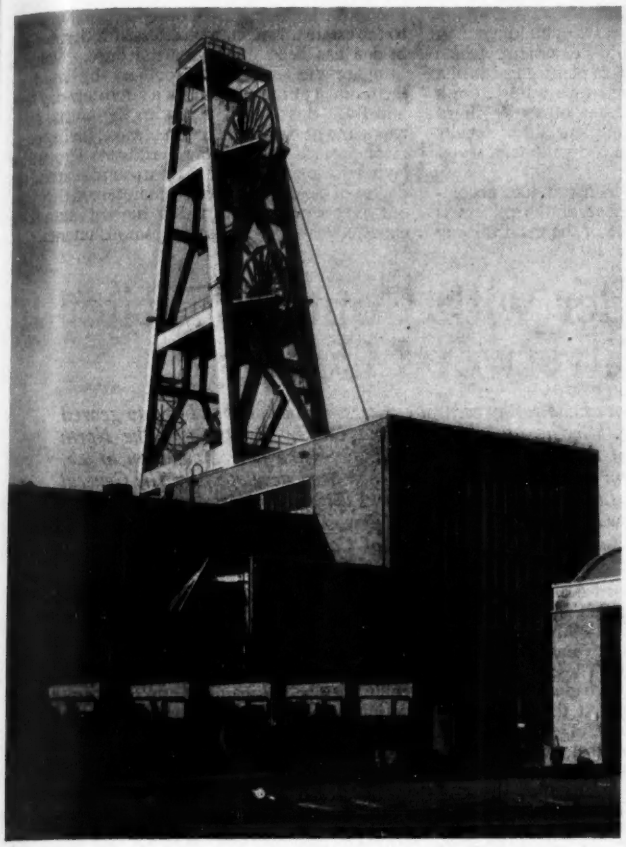


Fig. 8—New reinforced concrete head-gear for ground-mounted Koepe winding gear at No. 1 shaft

original steel head-frame has been replaced by the reinforced concrete head-gear, shown in Fig. 8, as it was unsuitable for the new duties. The electrical equipment for this winder was supplied by the Metropolitan-Vickers Electrical Company, Ltd., the main contractor for this Koepe winding plant and that at the Bradford colliery described in last week's issue. The mechanical equipment was made by the Fraser and Chalmers Engineering Works. It has a 26ft diameter pulley, which is driven through single-reduction helical gears by two d.c. motors, each with a rating of 1815 h.p. This electrical drive is operated on the Ward Leonard principle, and for it there has been installed a motor generator set driven by a 2450 h.p., 750 r.p.m., synchronous induction motor supplied directly at 6·6kV from the circuit breaker. Winder speed is controlled by a closed loop system with the excitation of the motor generator set controlled by a mercury arc rectifier. The new head-gear was built round the original steel structure, which was kept in service until the new plant was ready to operate.

Initially the plant is winding 250 tons of coal an hour from a depth of 915 yards at a rope speed of 35·2ft per second. In about ten years time, when the No. 2 pit ceases to wind coal from the 600-yard level, No. 1 shaft will be used to raise all the output. For this reason the new winding equipment has been designed for an ultimate capacity of 350 tons of coal an hour at a rope speed of 51·9ft per second. The shaft can then, if necessary, be fitted with two four-deck cages to take a net coal load of 12 tons.

The 610-yard deep No. 2 shaft is 16ft diameter and the amount of coal available at the 600-yard level justified its retention for coal winding as well as for servicing and downcast ventilation for an appreciable time. The equipment of the shaft has therefore been modernised by the replacement of the original steam winding gear by an electrical winder; the replacement of the two-deck cages by three-deck cages; and the construction of a new headgear of reinforced concrete to replace one of steel which was structurally unsound. The drum winding gear now in use has a diameter of 15ft with a width of 10ft between flanges. It is driven through single-reduction helical gearing by a 1200 h.p., 407 r.p.m. synchronous slipring induction motor. With its maximum rope speed of 37·4ft per second this equipment is designed to permit an output of 165 tons of coal an hour. Dynamic braking equipment fitted on this winder controls its speed down to a very low figure and then the mechanical braking is brought into operation.

Under the reorganisation programme the 915-yard deep No. 3 shaft, which is also 16ft diameter, has been arranged for upcast ventilation, material supplies and man riding. Its steel head-gear has been replaced by a concrete structure and the previously used steam winder replaced by an electric winding equipment similar to that fitted at No. 2 shaft. With a rope speed of 37·4ft per second this winder makes it possible to raise 900 men an hour from a depth of 915 yards, using two-deck cages accommodating eighteen men per deck. The reinforced concrete head-gear building incorporates the necessary airlocks for the passage of men and tubs. In order to reconstruct the fan drift and head-gear of this shaft the top 80ft of its brick lining had to be excavated and rebuilt. Whilst this work was in progress the shaft was maintained as a second exit for the working shaft.

For mine ventilation purposes a new fan drift has been built at the top of No. 3 shaft and the 150in diameter three-stage axial flow fan installed is designed for varying performances as required from time to time during the life of the colliery. At present the fan is supplying 410,000 cubic feet of air per minute at 6·25in water gauge; later it will be required to circulate 540,000 cubic feet of air at 11in water gauge, and ultimately 450,000 cubic feet of air per minute at 7in water gauge. To provide for the varying requirements two 750 h.p. electric motors have been installed to drive the fan singly in light periods, with one acting as a standby, or together during heavy duty periods.

To supply the compressed air required for the mine the new compressor house equipment includes three two-stage reciprocating compressors, each of 5230 cubic feet of air per minute capacity at 80 lb per square inch, and driven by a 960 h.p. motor. As the tub decking gear, airlock doors, &c., are all pneumatically operated, an auxiliary compressor set for lighter off-peak loads has been provided. This set consists of a motor-driven two-stage compressor capable of supplying 2700 cubic feet of air per minute at 80 lb per square inch. The compressors deliver into two air receivers, from which the underground supply of air is taken down No. 3 shaft by a 16in air main. Provision has been made in the compressor house for the installation of a further set should it be required, and also for another 16in main down No. 3 shaft. In planning this plant it was borne in mind that, should the rate of gas emission at the colliery ever become too high to justify the use of electric power, capacity is provided to enable compressed air to be used for operating underground equipment. Sufficient capacity had also to be provided for the eventual use of pneumatic stowing in one of the seams of the mine.

The complete electrification of the mine has necessitated the construction of a new substation, to which power is supplied at 6·6kV from three feeders. There are two transformer feeders of 33/6·6kV, each of 7·5MVA capacity, with the transformer situated at the colliery substation and the 33kV supply obtained from the new Bold power station. A third feeder being used as a standby comes from the Hill Moss substation and consists of two parallel 6·6kV cables. When the colliery is fully developed it is anticipated that its maximum demand will be 8000kVA at 0·9 lagging power factor. This compares with the maximum demand of 850kVA prior to the reorganisation scheme.

For receiving and storing run-of-mine coal three reinforced concrete coal bunkers, each with a capacity of 400 tons, have been built, and new tippler equipment for the mine cars installed in the surface tub circuits of Nos. 1 and 2 shafts. Facilities have also been provided for the importation of foreign coal by rail or road, and the contents of the railway wagons are discharged by tipplers on to conveyors leading to the run-of-mine coal bunkers. The tipplers for the tubs from Nos. 1 and 2 shafts discharge on to inspection belts delivering to two 48in belt conveyors, each of which is designed to handle up to 350 tons of coal an hour. The inspection belts can be arranged to discharge on to either of the 48in conveyors, and these conveyors can deliver either run-of-mine coal to the storage bunkers or dirt to a pit dirt storage hopper.

Coal is fed from each bunker by a vibrating feeder on to a conveyor leading to a sizing screen, from which the oversize is delivered to an

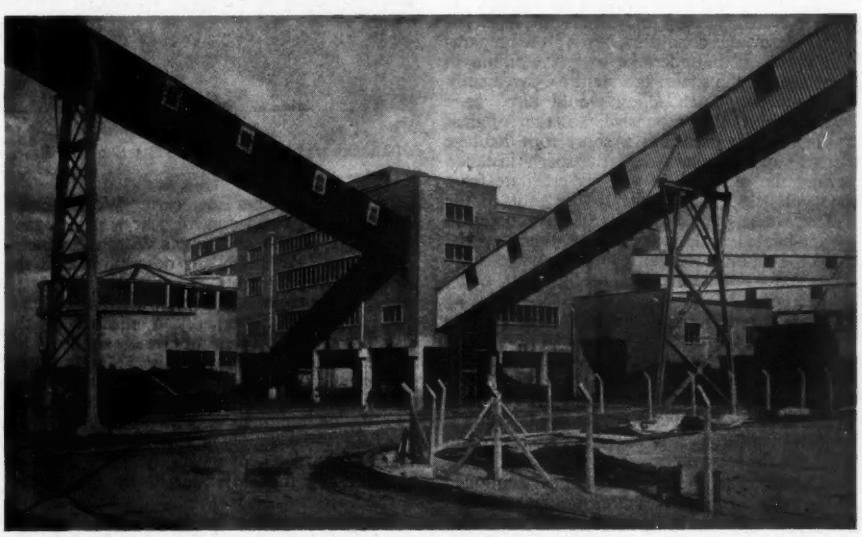


Fig. 9—Coal preparation plant for handling 350 tons of coal an hour at Bold colliery. Centrifuged ½in to ¼mm smalls from this plant are delivered directly by overhead belt conveyors to the nearby Bold power station

inspection belt and pick breaker. With this arrangement the screened minus 8in coal, and the plus 8in coal, after being cracked to minus 8in, are delivered on to a common conveyor belt for transport to the preparation plant. Stones picked off the inspection belt are conveyed to a belt used for taking the contents from the pit dirt hopper for disposal. At present this pit dirt is dumped on a disposal ground adjacent to the mine, but it will at a later date be returned to the mine workings for pneumatic stowing.

The coal preparation plant (Fig. 9), installed by the Coppee Company, Ltd., is designed to handle 350 tons an hour. In it the 8in by 2in coal is washed by the Dutch State Mines "slimes-tailings" process and the 2in by 0 is washed by the Baum system. Froth flotation is provided for treating the fine coals, and washed smalls are centrifuged. These ½in to ½mm smalls are centrifuged to give the maximum dewatering in preparation for transfer to the new power station adjoining the colliery, where they are required for pulverised fuel. Any degradation due to centrifuging these smalls with a ½in top size is not therefore disadvantageous, as they are either pulverised or reserved for carbonisation, and size is not of material importance. Coal is delivered from the plant in the following screened sizes: 8in by 4in, 4in by 2in, 2in by 1in, and 1in by ¼in. Four loading conveyors for the different sizes serve rail wagon tracks at one end of the plant, and at the feed end of the preparation plant arrangements have been provided for loading the raw coal directly into rail wagons should the plant break down. Provision has also been made for the tipping of rail-borne coal for blending directly with the washed smalls. The washed smalls for the power station are conveyed by belt from the preparation plant to a junction tower, where the weight of coal delivered is recorded by batch weighers. A further conveyor receives the coal from the weighing machines and delivers it to the power station bunkers. At present a maximum of 200 tons of coal an hour is being supplied from the mine to the C.E.A. for the power station, and sidings have been provided for the import of fuel should the demand at any time exceed the supply available from the colliery.

An extensive system of sidings has been laid to serve the colliery, and this provides sidings accommodation for the coal preparation plant, which has been built parallel to the main railway line, as well as sufficient storage capacity for empty wagons to cover one and a half days' requirements.

The new coal preparation plant is situated at the end of the original screening plant for the mine, which had to be kept in service until the new plant was in operation. It was decided to retain the original gravity feed of rail wagons from the empties sidings down through the new plant, but the natural slope of the site was insufficient for the continued gravitation of the wagons after filling, to the new train marshalling sidings. It was therefore necessary to provide some means of adjusting ground conditions beyond the preparation plant or to undertake extensive filling in front and on the site of the plant to give a sufficient incline. Such filling would have been both difficult and expensive, so the original site layout was used and a short rope haulage system up a steep incline has been installed beyond the plant. The wagons gravitate from the coal preparation plant to the foot of the incline, where they are automatically coupled to a rope-hauled mule, which hauls them up the slope. At the top of the incline the wagons are released to gravitate down to the marshalling sidings.

Before the mine was reorganised there were no landsale facilities at the colliery, but landsale bunkers with a capacity of some 400 tons have now been provided, and these bunkers are fed directly from the coal preparation plant by a conveyor. At present this side of the organisation is handling 3000 tons a week of both bagged and bulk coal for removal by road vehicles.

In addition to the plant buildings mentioned above, practically all of the original surface buildings have been replaced and the new buildings in service include workshops and stores, offices, a powder magazine, pit head baths, a canteen, a medical centre, a locomotive shed, mine car repair shop, materials stores, and a number of other smaller service buildings. A comprehensive fire protection system, which serves the whole of the surface plant, consists of a large pressure main supplied with water from a pumping plant. In the event of any hydrant being operated the pumping plant automatically starts up and delivers up to 625 gallons of water a minute into the main.

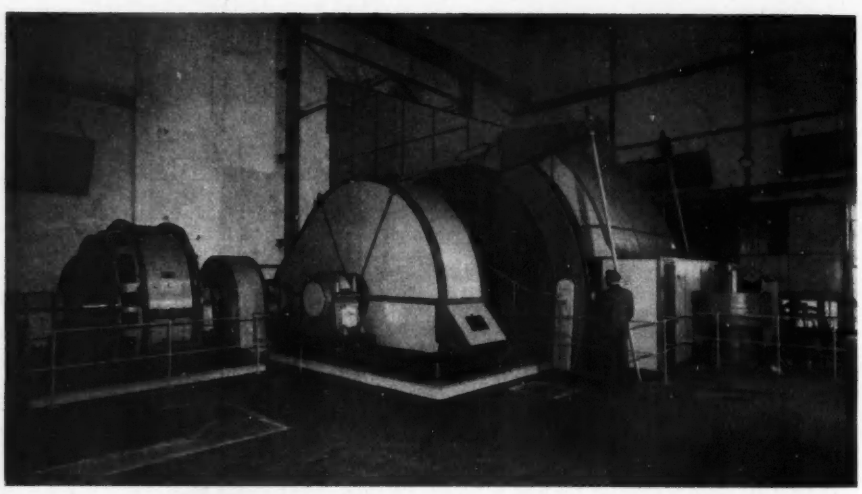
A new housing estate which provides accommodation for a large number of the miners is situated on the opposite side of the main railway line to the colliery, and in order to provide access to the estate a 75ft span prestressed concrete footbridge has been built over the lines. Vehicles bringing the men to the colliery by road set them down at the entrance of a large new pay hall, and from this hall they pass to the baths, lamp room and shafts under covered ways, giving complete protection from the weather. The whole layout of the surface plant, its surroundings and the degree of cleanliness which is maintained throughout is comparable with the highest standards expected in modern industrial establishments.

D.C. Winder with Control Exciter at Silverwood Colliery

A new system of speed control by control exciters has been applied to two geared Ward-Leonard d.c. winders at Silverwood and Cadeby Collieries in the North Eastern Division of the National Coal Board. It is the first application to d.c. winders of a system of speed control which has been developed by The General Electric Company, Ltd., and used for steel works drives. The installation described and illustrated below is at the East Shaft of Silverwood colliery. Similar equipment is in service at No. 2 shaft of Cadeby colliery.

TWO geared Ward-Leonard d.c. winders have been supplied and installed by The General Electric Company, Ltd., at Silverwood and Cadeby collieries in the North Eastern Division of the National Coal Board. These installations, which form part of the Board's extensive modernisation programme, are the first d.c. winders to use the new G.E.C. system of speed control through the medium of control exciters. This method of speed control has already been applied to steel works drives, including those of the temper mills at the Trostre and Velindre works of the Steel Company of Wales, Ltd.

The mechanical parts of the new winders at Silverwood and Cadeby were built at the G.E.C. Fraser and Chalmers Engineering Works, Erith, and the motors and control gear were designed and made at the company's Witton Engineering Works. Although our description and the accompanying illustrations relate particularly to the winder at the east shaft of Silverwood colliery, the information is equally applicable to the installation at No. 2 shaft of Cadeby colliery.



3700 h.p. geared d.c. winder at the East Shaft of Silverwood colliery, North Eastern Division, National Coal Board

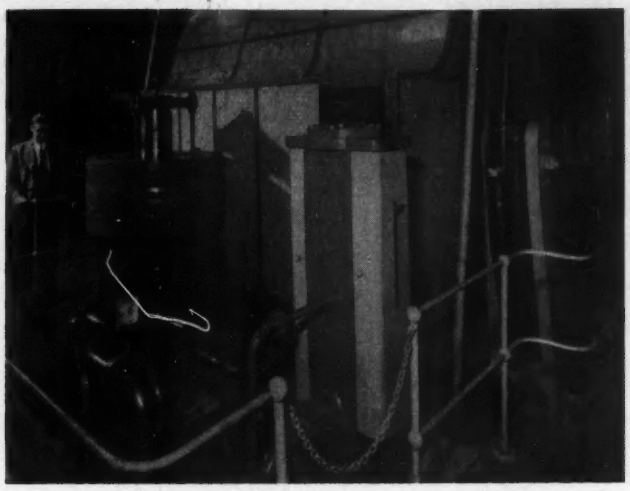
The winder is designed to raise 525 tons of coal per hour from a depth of 2299ft and is driven through single-reduction, double-helical gearing by a d.c. motor rated at 3700 h.p., 0/320 r.p.m. The 0/650V d.c. supply is provided by a 2650kW Ward-Leonard set, of which the 11kV synchronous driving motor is started by the reactor method.

There are two parallel drums, 18ft diameter, one being clutched and the other fixed on the drum shaft. An interesting detail is the method of rope grooving employed, whereby the rope is laid across the drum during coiling on the first layer. This grooving is designed to eliminate the undesirable effect of "rope flap," as experienced with the normal series of parallel grooves which have hitherto been employed for multi-layer coiling. The mechanical brakes operate on a variable-pressure system consisting, essentially, of two brake engines: one being a double-acting pressure engine which, for normal operation, applies both sets of brakes; and the other a standard weight-brake engine, which, in the event of changing winding levels, applies the loose drum brake so that the clutch can be withdrawn. The clutch engine and weight-brake engine are interlocked so that it is impossible to withdraw the clutch until the loose drum brakes are fully applied, or to release the brakes until the clutch is engaged.

The rate of application of the brakes during the high-speed period of the wind is controlled by a slow braking valve which is operated by cam gear and restricts the flow of oil from the brake engine. Rapid application of the brakes is possible during the acceleration or retardation periods.

Speed Control System

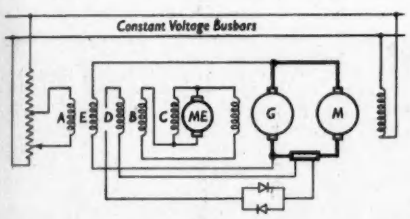
Speed control of the winder is effected by a control exciter system which is designed to combine the merits of the "three-field" generator with those of the "straight" Ward-Leonard arrangement. The control exciter system differs fundamentally from earlier methods of control in that a definite transition is made from an open-loop to a closed-loop system in which a



(Left) 2650kW Ward-Leonard set supplying direct current to the 3700 h.p. d.c. winder at Silverwood colliery. (Right) variable-pressure mechanical brake-operating gear for the 3700 h.p. winder

controlling input signal proportional to the required speed is compared with a signal proportional to the quantity actually obtained from the system output. Any discrepancy in these two quantities corrects continuously the output quantity. Since speed and voltage are closely related in large d.c. motors, the system as applied to winders depends basically upon voltage control. By compensating for the voltage drop in the loop circuit, this relationship may be made very close indeed.

The principles of the control exciter system are embodied in the basic circuit diagram reproduced here. It will be seen that the exciter *ME* is provided with several field windings, the resultant effect of which determines its degree of excitation and consequently its output to the field of the main generator *G* which supplies the winder



Basic circuit of control exciter system, with current limit characteristic, for winder drive

motor *M*. Field *A* is the control field and is energised by applying a pattern voltage. Field *E*, which opposes field *A*, is excited by the main generator *G*. The series field *B* (which includes a stabilising section) and the stabilising shunt field *C*, jointly serve to prevent hunting, while the field *D*, which is shown connected in series with forward and reverse rectifiers across the shunt in the generator-motor loop, is the current-limit field.

When the driver moves his lever from "stop" to the full "on" position, maximum pattern voltage is applied to winding *A* of the control exciter *ME*. This voltage causes the control exciter to supply an initial forcing voltage to the field of the generator *G* so that its output voltage builds up quickly and the winder motor *M* is accelerated rapidly: thus, the system ensures that the speed of the winder responds promptly to the movement of the driver's lever. As the voltage of the generator *G* increases, it applies an increasing excitation to the field *E* of the control exciter. Field *E* opposes field *A*, and the two are almost in balance; their resultant excitation, together with that of the stabilising fields, is designed to produce the requisite voltage in the generator *G* to run the winder motor at the desired speed as determined by the position of the driver's lever. Any change in the output voltage of the generator *G*, or in the pattern voltage, at once disturbs this state of balance and results in an immediate increase or decrease in the output of the control exciter and, consequently, of the generator, so that balanced conditions are restored rapidly and accurately.

Similarly, movement of the driver's lever from full "on" to "off" reduces the excitation of field *A* to zero, leaving field *E* to provide a high over-excitation in the reverse direction. This in turn forces down the excitation of the main generator *G*, whereupon the winder motor *M* regenerates and is quickly brought to rest.

The action of the stabilising fields is as follows. The series field *B* assists, and the shunt field *C* opposes, the control field *A*. When the generator field is changing rapidly, the current in the shunt field *C* rises far more quickly than that in the series field *B*, owing to the damping effect of the inductance of the generator field. Thus, the initial resultant of these two fields opposes the control field and the rate of response is damped so that over-shooting, in the event of sudden changes in the pattern voltage, is prevented. On the other hand, under steady running conditions, the resultant excitation produced by these two fields, *B* and *C*, is such that the requisite output of the control exciter is maintained. Accordingly, the exciter is nearly self-exciting, which has the effect of increasing the accuracy of the system because any change in the input to the control field *A* will result in full output from the exciter.

The current limit field *D* safeguards the machines by limiting the current during acceleration or retardation to a maximum safe value. When the current circulating between the winder motor and generator exceeds a predetermined value, the volt drop across the shunt causes the appropriate rectifier circuit to be conducting (since a metal disc rectifier requires a small but definite voltage in the forward direction before it can pass current). Then any further increase in the current in the motor-generator loop causes an appreciable current to flow in the field winding *D*. Since this field opposes the control field *A*, the output of the exciter is reduced, thereby limiting the voltage of the generator *G* to a value which ensures that only a safe maximum current will flow through the winder motor *M*. Similarly, when the plant is stopping and the motor begins to regenerate, the reverse current flowing from the motor to the generator is limited to the predetermined safe value.

Speed Control System Applied to Winder

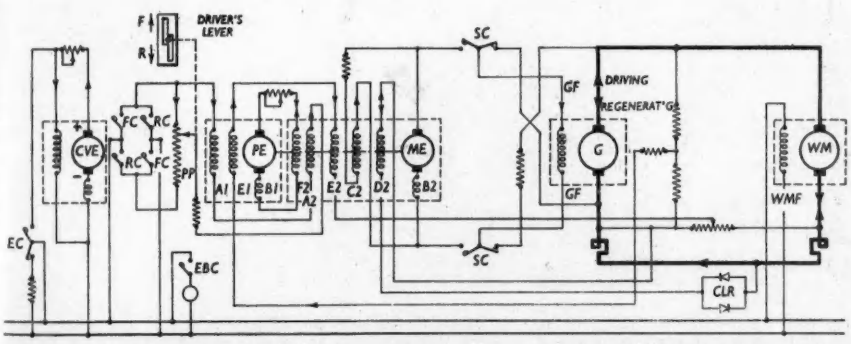
Because of the size of the winder motor and the degree of amplification required, two control exciters are installed and are connected in cascade.

The complete system is shown in schematic form in the second diagram reproduced here. The pilot exciter *PE* feeds the field system of the main control exciter *ME*, which in turn excites the main generator *G*. A constant-voltage exciter *CVE* supplies the field *WMF* of the winder motor *WM*, the brake solenoid, and the operating coils of the various contactors and relays. With the winder motor at standstill and the driver's lever in the "off" position, the pattern potentiometer *PP* is de-energised, and the customary suicide connection through contactors *SC* is made for the generator field. Movement of the driver's lever first actuates the appropriate contactors to connect the main generator field across the armature of the control exciter *ME*, and the potentiometer *PP* to the constant voltage line in the appropriate sense for the required direction of rotation. The selected voltage, as determined by the position of the driver's lever, is now applied to the pattern shunt field *A*1 and *A*2 of the pilot exciter *PE* and main exciter *ME*, respectively.

The pilot exciter immediately energises the field *F*2 of the main exciter. At this stage the three fields, *A*1, *A*2 and *F*2, are unopposed so that a forcing voltage is built up across the main generator field *GF* and a voltage appears at the generator terminals. It should be noted that excitation of the exciter *PE* and *ME* is further assisted by the series fields *B*1 and *B*2.

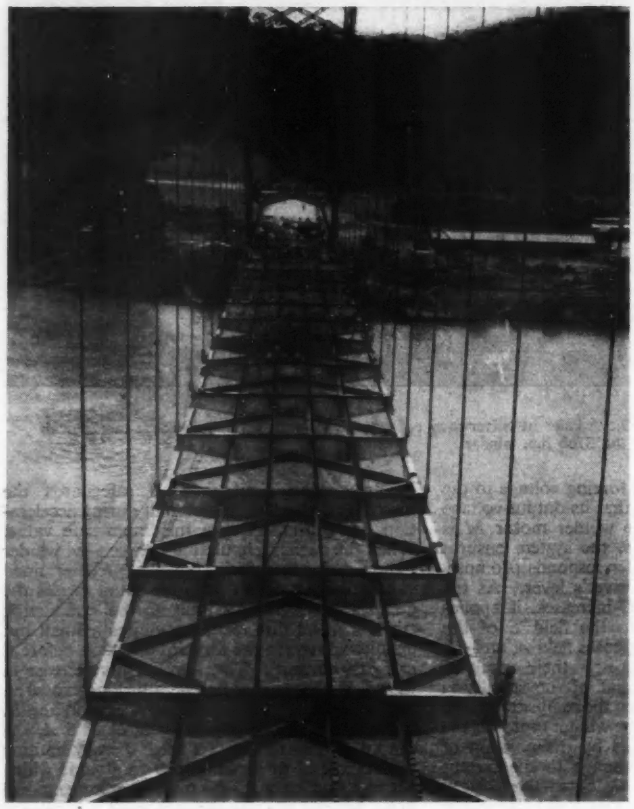
While the mechanical brake of the winder is applied, the current flowing in the generator/motor loop circuit will be limited to a predetermined value (usually about twice full load) by the current limiting field *D*2, which is supplied through the rectifier *CLR*, as previously explained.

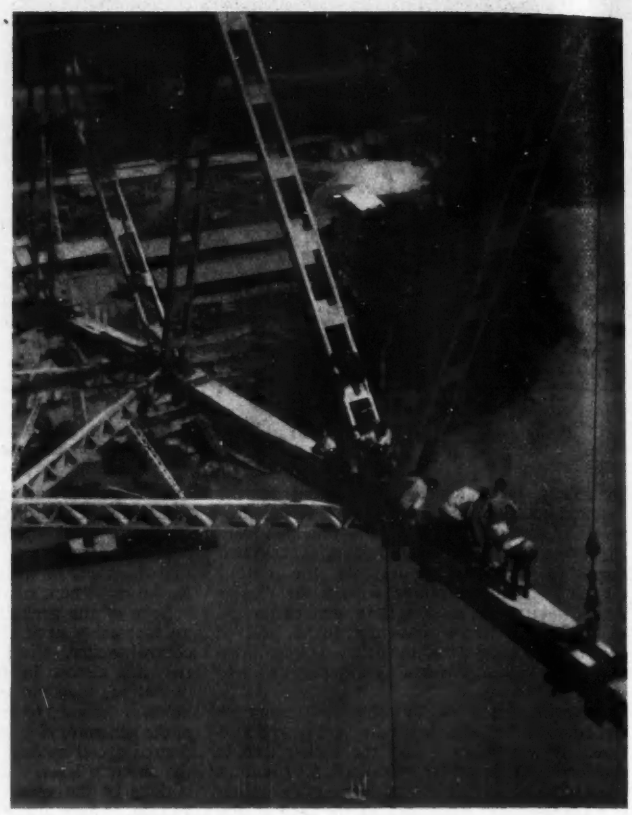
On releasing the brake, the motor *WM* will begin to accelerate and generate a back e.m.f., but the combined effect of the control exciter



Diagrammatic arrangement of control exciter system for 3700 h.p. winder at the N.C.B. Silverwood colliery

CONSTRUCTION OF STEEL ARCH VOLTA BRIDGE





The deck steelwork, prior to construction of the reinforced concrete deck which forms the upper flange of a composite design, is shown (upper left). Closure of one of the lower chord joints at mid-span is shown (above right), and the lower view shows construction of the deck well advanced, and gives a good idea of the attractive appearance of the completed main span and approach spans. The bridge will carry an indivisible load of 180 tons

fields *A2*, *F2* and *D2* is such that the excitation of the generator *G* and, consequently, its voltage, is automatically increased at the necessary rate to maintain the required current in the generator/motor loop circuit.

As the speed of the motor rises and the generator voltage increases, the reset fields *E1* and *E2* of the control exciter set are energised. The voltage applied to these fields is made proportional to the back e.m.f. of the motor by means of a resistance network so that it reflects very closely the speed of the motor. The fields *A1* and *A2* are now opposed by *E1* and *E2*, and acceleration at constant torque continues until the motor reaches the desired speed. At this speed, the fields *A1* and *A2* are very nearly balanced by *E1* and *E2*, a very small difference sufficing to maintain the requisite excitation and the voltage of the generator *G*. Throughout the acceleration period the current-limiting field *D2* opposes the resultant field produced by the windings *A2*, *E2* and *F2*, so that the current flowing through the motor is limited to the desired value. Furthermore, the fields *A2*, *E2* and *F2* are so proportioned in relation to the characteristics of the pilot exciter *PE* that the main exciter *ME* gives maximum output whenever the speed of the motor *WM* differs from the required speed by more than 10 per cent. This slight "looseness" facilitates manœuvring at low speeds by allowing a measure of torque control.

A similar sequence of events takes place when the winder is running at a steady speed and the driver's lever is returned to stop. Thus, at all times the winder speed is made to follow the position of the driver's lever very accurately, being subject only to temporary divergence due to the current limit characteristic.

Volta Bridge

An important event in the development of communications in the Gold Coast took place on January 25, when the Governor, Sir Charles Arden-Clark, formally opened the Volta Bridge in the presence of the Prime Minister, Dr. Kwame Nkrumah. This steel arch structure, with a main clear span of 805ft, carries the trunk road to Togoland over the River Volta, and replaces a vehicle ferry which was becoming increasingly inadequate for the growing volume of road traffic.

Joining the arch of the Volta River Bridge. Here we show the cylindrical joint in one of the upper chords of the arch. The first stage in closure was to bring the faces of this joint to a distance of 10in apart

Brief details of the bridge, the arch of which was closed on July 26, 1956, were given in The Engineer of January 4. We illustrate here the final stages in the construction of the arch. The two halves, which had been tied back to temporary anchorages, were built out from each bank until the faces of the special cylindrical joint between the centre upper chord members were 10in apart. The gap between the lower chord members was measured, and the amount of packing required in the cylindrical joint to produce the correct stress distribution in the arch after closure was calculated. The ties were then slackened until the upper joint closed, and this joint, acting as part of a 4ft diameter pin, permitted rotation of the upper chords while the ties were further slackened to allow the lower chord joint to be made. The cylindrical joint just before closure is shown herewith.

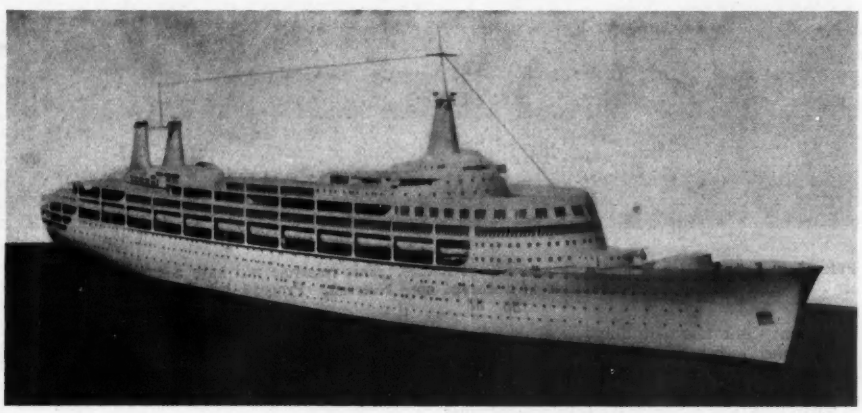
After the closing of the arch, steel cable hangers at 35ft intervals were suspended from the lower chords, and the steelwork which supports the bridge deck was hung from these cables. The deck is designed as a composite structure, with a reinforced concrete slab, joined to the longitudinal stringers by shear connectors, acting as the upper flange. The cross girders and stringers, like the arch members, are of high tensile steel. The carriageway is 22ft wide and the whole structure is designed to take the exceptionally heavy loading defined as "HB45" in British Standard No. 153, which means that it can safely carry an indivisible load of 180 tons. If the power development envisaged by the Volta River Project is carried out, a hydro-electric installation of some 700MW will be built 5 miles upstream of the bridge, and loads of this sort will be common.

The bridge, which includes three reinforced concrete approach spans of 50ft on each side of the main span, and the 5½ miles of approach roads, by which the ferry is by-passed, were all completed in just under two years, at a total contract cost of £550,000.

The joint consulting engineers to the Government of the Gold Coast for this project were Sir William Halcrow and Partners, and Freeman, Fox and Partners; the main contractor was Dorman Long (Bridge and Engineering), Ltd.

45,000-ton P. & O. Liner for Australian Service

Since the end of the second world war the Peninsular and Oriental Steam Navigation Company has added three new liners, each of about 29,000 tons gross and about 22 knots speed, to its fleet, to maintain its services to Australia. However, both the "Strathnaver," built in 1931, and the "Strathaird," built in 1932, are approaching the end of their useful economic life as passenger ships, and that raised the problem of replacement. This has received close attention, and on Wednesday of last week the company announced that it had decided to build a new 45,000-ton passenger liner with a service speed of 27¼ knots and that the order had been placed with Harland and Wolff, Ltd. The size and speed, it was stated, was arrived at, apart from the relationship between speed and length, after careful consideration of the future of migration to Australia, the effect of air competition and the economic factors such as first cost and earning capacity. Two such ships, it was thought, would be equal to three "Iberia" class ships, in that they would provide the same number of berths per year but would require fewer crew and involve less capital cost. As already mentioned, the ship is intended for the Australian run, but it is planned, in conjunction with the Orient Line, to extend the service to Auckland, then across the Pacific, with intermediate calls, to Vancouver and San Francisco. The speed selected is expected to reduce the voyage to Sydney from four to three weeks, and it is estimated that the round voyage will take ninety-eight days.



Model of 45,000-ton P. & O. liner for the Australian service

The new ship will have an overall length of 814ft, a length between perpendiculars of 740ft, a beam of 102ft and a load draught of 31ft 6in, and will be propelled by turbo-electric machinery developing a total of 85,000 s.h.p. The photograph which we reproduce of a model of the ship give a general idea of the ship as she will appear when completed, and, as can be seen, the machinery is placed aft, there being divided uptakes to twin funnels. The ship is to be of all-welded construction and there will be thirteen decks, including a superstructure largely built of aluminium alloy, and three cargo holds forward having a total capacity of 150,000 cubic feet, this amount of space being related to the amount of cargo which can be handled while the ship is in port, embarking and disembarking passengers. Two of the holds are arranged with loading doors in the ship's side. A total complement of 3210 will be carried, including 600 first-class and 1650 tourist-class passengers and 960 crew, and the whole of the accommodation for passengers and crew will be air conditioned. Most of the first-class cabins, mainly single, two and three-berth rooms, will have private bathrooms or showers, while the tourist passengers will be accommodated in two and four-berth cabins and a few single-berth rooms. The design and decoration of the public rooms is to be undertaken by Sir Hugh Casson in association with Messrs. McInnes, Gardner and Partners. Lifeboat stowage, it will be noticed from our illustrations, is not traditional, but arranged three deck heights lower down and this will not only allow for easier embarkation of passengers, should the need arise, but will also improve stability. Two sets of Denny-Brown stabilisers are to be fitted.

Steam for the single-stage turbines driving the two main alternators will be supplied at 700 lb per square inch gauge and 950 deg. Fah., and it will be possible for the ship to maintain a speed of about 23 knots, using one alternator. It is understood that the propelling machinery is to be supplied by the British Thomson-Houston Company, Ltd. Oil fuel arrangements provide for the carriage of between 7000 to 7500 tons of fuel, which should give the ship a radius of action of about 10,000 miles. Electric power for engine-room and ship auxiliary machinery, and for ship and domestic services, will be provided by four 1500kW, 440V, 60 c/s turbine-driven alternators.

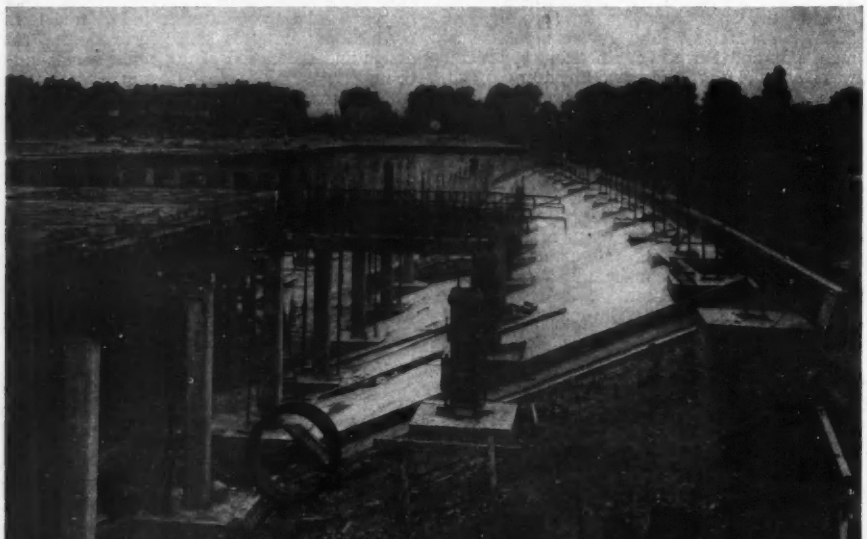
The keel of the ship, which is at present known as No. 1621, will be laid in September of this year and delivery is expected towards the end of 1960.

Natural Gas in Yorkshire.—It is announced by Imperial Chemical Industries, Ltd., that it has agreed with B.P. Exploration Company, Ltd., to undertake joint exploration for natural gas in the Whitby district in Yorkshire. The results of recent seismic reflection surveys are held to justify further drilling and as a first step a bore-hole in Robin Hood's Bay is to be deepened.

Progress of the Metropolitan Water Board's New Works during 1956

AT about this time each year, THE ENGINEER customarily publishes a review of the previous twelve months' progress made with the various new works under construction for the Metropolitan Water Board. During 1956 two large schemes which have been described in previous years, namely, the 90 m.g.d. filtration works at Ashford Common and the 102in raw water main from the Thames to the Lee Valley, continued to make progress. The total cost of these schemes is expected to be about £4,500,000 for the filtration works and just over £5,000,000 for the main. There is much of technical interest in both of them, but it is not intended to describe them at length here, since previous articles have already given a great deal of information. Progress in 1956 may, however, be briefly noted.

At Ashford Common, preparations were being made for bringing the works into permanent use with single-stage filtration, until installation of the twenty-four micro-strainers is achieved. It was planned to bring the first units into operation early this year. Completion of the whole scheme is scheduled for 1958.



Filtered water balancing and storage reservoir at Barnes. This reservoir will have a capacity of 10½ m.g. It utilises the embankments of a disused open reservoir. Progress last July is shown

The 102in raw water main from the Thames to the Lee Valley is to be constructed in tunnel. Its purpose is to replenish the Lee Valley reservoirs, when the flow of the Lee is insufficient for that purpose; the Lee is regarded as a source which is likely to diminish, and the demands of areas supplied from the Lee Valley are increasing. The main interest of the scheme lies in the method of construction, previously described in this journal, involving a deep tunnel in the London clay lined with precast concrete segments. This technique is substantially cheaper than more conventional methods, and other examples of its use are beginning to appear in the Board's new works. In the case of the Thames-Lee tunnel it will permit a gravitational flow as far as the shaft near Lockwood reservoir at the Lee Valley end of the deep tunnel. The tunnel will have a total length of about 33,600 yards and will convey 70 m.g.d.

Work continued during the year on the two contracts let by the Board in 1955 for the construction of approximately 4 and 4½ miles respectively of main in tunnel. By the end of the year 5888 yards of tunnel were built by A. Waddington and Son, Ltd., and 3376 yards by Kinnear Moodie and Co., Ltd. The total length of tunnel constructed, including two experimental lengths, was 10,567 yards.

At the Lee Valley shaft further mains will be needed between the pumps and the storage reservoirs. A contract was awarded to William Press and Son, Ltd., during the year for the laying of 3¾ miles of 54in internal diameter steel-lined main in trench from Lockwood pumping station to Chingford South pumping station (for pumping either to the William Girling or King George's reservoirs), and ½ mile of 54in internal diameter steel-lined main to High Maynard reservoir, laid in trench alongside the former main, and 36in internal diameter cast iron branches to Lockwood and Banbury reservoirs. Orders were placed by the contractor for the steel pipes and other materials that are required before the site work can be commenced. Tenders were invited for the construction of a further length of main in tunnel of approximately 4¾ miles from a point in the Board's works at Hampton to a point approximately ½ mile north-east of a shaft in Richmond Park. The tenders will be due early in February.

WALTON SOUTH RESERVOIR

Last November, the Board accepted the tender of W. and C. French, Ltd., for the construction of Walton South reservoir. This scheme is comparable in size to the two just mentioned, its estimated cost being over £3,000,000. It will store 4300 m.g., when completed. The Board has been endeavouring to increase the storage capacity of its reservoirs for some years, but has been hampered by restrictions on capital expenditure, and work of this nature has inevitably lagged in the post-war years. South Walton reservoir illustrates this, for its construction was started in 1938. When work was closed down at the outbreak of war, about 1¼ miles of cut-off trench had been completed and about 953,000 cubic yards of back fill had been placed.

The reservoir site is on the Thames Valley alluvial plain and the geological strata consist of brick earth on top of water-bearing surface gravels overlying the London clay. The site is wholly within the area of the urban districts of Walton and Weybridge, and Esher. The banks of the reservoir will be formed of ballast dug from the interior of the site and rendered watertight by a clay core, which in turn will be extended below ground to tie into the underlying London clay. The inner face of the bank will be protected from erosion by concrete slabs 6in in thickness. The exterior of the bank will be covered with soil and sown with grass. The leading particulars of the reservoir are listed in the table. The bottom of the reservoir will slope at a uniform rate to the outlet and all holes or depressions will be filled in.

Leading Data for Walton South Reservoir

Capacity	4,300 m.g.
Water area	317 acres
Top water level	77·50 O.D. (Newlyn)
Top level of bank	83·50 O.D. (Newlyn)
Mean depth	57½ft
Length of bank	2¾ miles
Total volume of bank	4,221,000 cu. yd.
Mean height of bank	46ft

Water will be abstracted from the River Thames through the existing Walton intake and pumped from the Walton pumping station direct to the reservoir through a deep tunnel commencing at a shaft near the south-east corner of the pumping station. The internal diameter of the tunnel will be 100in and it will be lined with concrete segments. It will be driven through the London clay and will pass under the Knight reservoir at a depth of about 120ft below the bottom of the reservoir. The length of the tunnel from Walton pumping station to the inlet of the reservoir will be 1072 yards.

The water will then be discharged into the reservoir at the north-west corner through three groups of nozzles, each consisting of three 36in nozzles fixed at varying inclinations, as well as through two 72in diameter concrete pipes carried out into the reservoir. The design of the inlet arrangements is based upon experiments made by the Board's staff during the past ten years, and the object is to prevent the formation of thermal stratification or to break up any stratification of the water which may occur.

The outlet will be formed by a wet tower situated at the north-east corner of the reservoir and connected with the bank by a bridge. The openings in the tower will enable water to be drawn off at four different levels. In addition, a 72in diameter concrete pipe laid on the floor of the reservoir will enable water to be drawn from the centre of the reservoir if and when required.

The outlet tunnel will consist of a concrete-lined tunnel 100in in diameter about ½ mile in length and driven at some 130ft below the surface of the ground. The tunnel will terminate in a shaft on land owned by the Board at a place known as "Boorman's Field," adjacent to the Hurst Road. From this shaft connections (which will be built under a separate contract) will be made to the existing mains to Walton, Surbiton and Hampton filter beds.

To store the greatest possible quantity of water on the site, the floor of the reservoir will be excavated to some 15ft below the level of the ground. Part of this material will be used to form the banks, but the remainder, amounting to about 1,750,000 cubic yards, which will consist of ballast, clay, overburden (a sandy loam) and top soil will be disposed of by the contractor partly in adjacent ballast pits and partly by dumping on spare land belonging to the Board. In view of the value of the ballast and top soil the dumped materials will not be mixed, but will be available at a later date for sale by the Board, or for its own use. At least 100,000 cubic yards of top soil and 100,000 cubic yards of ballast are to be so retained.

To facilitate research into the observation of the stored water and to enable continuous observations on the temperature and other physical qualities of the water to be obtained, three limnological observation towers, each consisting of four concrete columns supporting a platform about 14ft square will be constructed inside the reservoir.

On the east side of the reservoir it will be necessary to divert the Walton/Molesey Road for a distance of about 1000 yards. This diversion will take the road through part of a worked-out ballast pit and a portion of the reservoir bank will also be carried out in filling in this pit. Special arrangements are included in the contract for carrying out this work, which is required to be started as soon as possible after letting the contract.

The construction of the bank will be strictly

controlled to a specified schedule to allow proper time for consolidation and the contractor is given five years to complete the reservoir. Tenders were invited for three different methods of constructing the clay core to the embankment to allow the contractor to take full advantage of modern methods of earth compaction. These were : puddle clay core above and below ground ; mechanically compacted clay core above and below ground, and puddle clay cut-off below ground and mechanically compacted clay core above ground. The tender accepted was for mechanically compacted clay core above and below ground. The engineer's order was given for the commencement of contract work on January 1, 1957.

Other Works

Other schemes under construction during the year included one to improve the supply in North-East London, at an estimated cost of £475,850. This scheme involves extension of Woodford pumping station, a new service reservoir at Chigwell, trunk and interconnecting mains and a booster station. The small booster station was constructed and two electrically driven pumps installed in 1955. During the year the laying of the interconnecting mains in the Chigwell area, consisting of 3935 yards of 15in main and 2574 yards of 12in main, was completed. Work was commenced on laying the trunk mains from Woodford to Chigwell, and by the end of the year 815 yards of 18in main, 6200 yards of 15in main and 350 yards of 24in main were laid.

Work was continued by W. and C. French, Ltd., on the construction of the 4·8 m.g. service reservoir at Chigwell. The mass concrete main walls and the division wall were completed, the roof of the east half of the reservoir and 40 per cent of the roof of the west half were constructed and the floor was laid on the east half. Work was proceeding on the asphalting of the roof and its soil covering and also on the formation of the surrounding embankments. In November work was commenced on the building of the extension of Woodford pumping station for the additional electrically driven pumping plant.

At Knockholt, the second stage of the main-laying scheme described last year was completed, and so was the 5 m.g. service reservoir, which was being tested for watertightness. Construction of the 3½ m.g. covered contact and balancing tank at Stoke Newington was also completed, pumping machinery was installed, and also part of the chemical treatment plant. At Hampton, reconstruction of the slow sand filter beds continued, and by the end of the year eleven beds were reconstructed and work was in progress on two more.

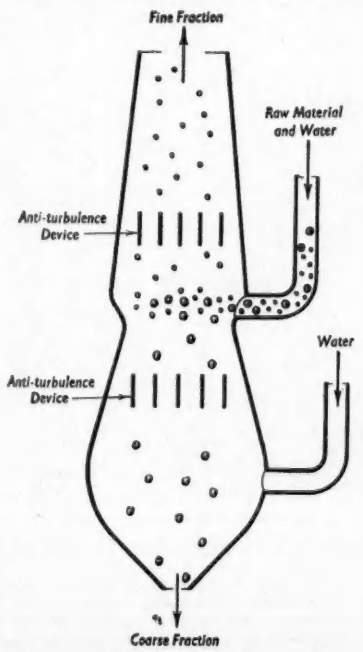
At Barnes, construction of the new filtered water balancing and storage reservoir by Howard Farrow, Ltd., made very good progress, and the floors, walls and roof of the reservoir were completed and soiling was in progress. This work is shown in the illustration on page 186.

A second borehole was sunk at North Orpington, improvements to the pumping station at Stoke Newington were finished, and the interim remodelling scheme at Hammersmith pumping station was substantially completed. At Putney Heath the building of a booster pump house was completed and the new electric plant was installed and set to work. Other works in progress included the raising of the puddle wall of High Maynard reservoir, the construction of a suction tank at Clam Fields, Woolwich, and the remodelling of Turnford pumping station.

All of the works described were under the direction of the Metropolitan Water Board's chief engineer, Mr. H. F. Cronin. The consulting engineers for the Thames–Lee tunnelling works are Sir William Halcrow and Partners.

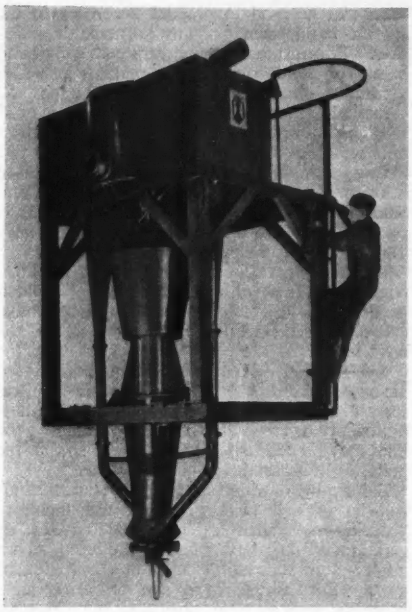
Hydraulic Separators for Grading Sands and Powders

THE lower limit at which separation of different sizes of particles is practicable on a commercial scale by normal processes of screening is at about a particle size of ¼in. Sands below this limit owe their grading characteristics to natural causes, and so particular properties are associated with sands from certain strata or quarries. Thus sands in use to-day are generally "natural" products, as far as grading is concerned, and are chosen according to the particular use involved, some industries needing the finest sizes and others requiring a coarser sand. In concrete making, a preponderance of the smallest sizes—below, say, mesh 150—is deleterious especially for concrete which must be frost-resistant ; in a recent article on an Austrian hydro-electric scheme* we noted that a new kind of plant which graded the sand hydraulically had been successfully incorporated in the aggregate preparation plant installed for the construction of the main dams of the scheme. The plant, known by the name of "Rheax," has other applications besides the preparation of sand for concrete making, including the grading of fine clays, kaolin, foundry sands, and so on, and in some filtration and ore preparation processes ; it extends the range of separation which is feasible on an industrial scale down to particle sizes of mesh 300. We learn that such plant is now available in this country, and is eventually to be manufactured under licence by Millars' Machinery Company, Ltd., Pinners Hall, London, E.C.2.



Diagrammatic section of vertical separator

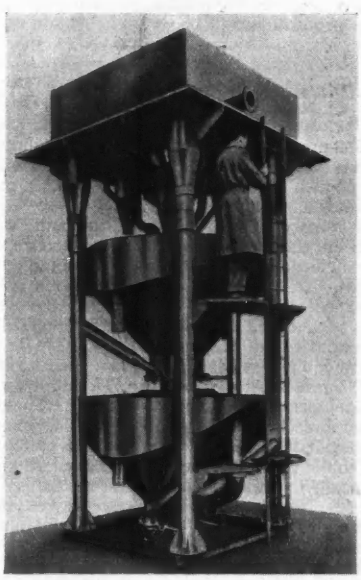
The various designs of "Rheax" apparatus are thus intended for separating the fractions below about ¼in maximum size. The principle of the apparatus is shown most clearly by the vertical unit, illustrated diagrammatically. The rate of settlement of small particles of uniform shape and density suspended in a fluid is related to the particle size, according to Stoke's law. This principle cannot, however, be applied directly for separating different sizes. The expedient made use of here is to introduce ungraded particles into the apparatus in which there is an upward flow of water at a rate calculated to keep the particle of the precise size at which separation is to be achieved in suspension were the separating chamber a cylindrical tube.† However, the upper part of it converges slightly, so those particles initially carried upwards (i.e. "fines") are slightly accelerated once separation is achieved, and vice versa for the coarse fraction. Micaceous particles, which are flaky and of low settling velocity, are carried in to the fine fraction to a large extent ; this, of course, is an advantage in separation for concrete making. Very accurate separation is claimed.



Vertical apparatus for hydraulic separation of sand

The vertical apparatus is generally used to separate into fractions above and below about mesh 25. It can be made in sizes capable of treating about 50 tons per hour for this class of separation. When separation in smaller sizes is required, however, the capacity of the vertical apparatus falls of, and the horizontal apparatus is used instead. This latter design is less precise in the separation it achieves, and so is generally used with two or more in series. A slight upward flow of water is introduced at the base of a funnel-shaped container (being in fact an input compensating current), and the ungraded sand is introduced in suspension through a radial deflector at the top, so that the fine particles are carried over the sides of the "funnel" and the coarse flow in a continuous discharge from the base. Separation sizes down to mesh 300 and capacities of 50 to 60 tons per hour can be achieved by pairs of these devices.

Various combinations of horizontal and vertical



Combination of single vertical separator and two pairs of horizontal separators. The complete apparatus will treat about 25 tons per hour, separating, in this case, into fractions above 1mm, 1mm to 0·1mm, and less than 0·1mm

* "The Glockner-Kaprun Hydro-Electric Scheme," Part II—The Engineer, September 21, last.

† The same principle has been used in the laboratory in an apparatus known as Crooke's elutriator.

units can be used in practice according to the specific requirements of any particular application. For instance, we illustrate a compound plant for sand for concrete making in which separation into sizes of ⅛in—mesh 52; mesh 52—mesh 150; and minus mesh 150, at a rate of 25 tons per hour are achieved. The central vertical unit separates the coarse fraction, and the fine fraction from it is passed through either pair of horizontal units to give the separation above and below mesh 150. Material below mesh 150 is rejected; the two pairs of horizontal units have the same capacity as the one vertical unit.

In other separations elaborations of the horizontal separation principle are used. Should it be desirable to obtain a coarse product almost entirely free from fine grains, for instance, the cone separators are used in series, so that the coarse fraction is recirculated, using compressed air or armoured pumps, the number of identical separation stages being a measure of the ultimate uniformity of the coarse fraction. Similarly, the fines may be additionally recirculated so that the precision of separation will be complete.

Being a hydraulic separation, the effluent sands will be of high water content, and therefore "thickeners," such as mechanical rakes or variants of dewatering cones, are used as an immediately succeeding stage in the treatment cycle. But storage in a silo or stockpile is generally sufficient for drainage, since natural dewatering is accelerated owing to the absence of silt, and handling properties, particularly at hopper outlets, consequently improved.

An account of the theory of this separation process has been given by the French engineer, Monsieur Leviant, in *Construction* of April and May, 1955. Following the Tromp method of assessing the accuracy of mineral ores dressing, he plots the percentage chance of any grain passing into the fines fraction (the smaller the grain the nearer to 100 per cent, &c.), against a function of its particle size. Then, assuming a parting size, for a perfect separator the "curve" will be a horizontal straight line at 100 per cent, a vertical line at the parting diameter, and a horizontal straight line at 0 per cent. All curves plotted for "Rheax" separations, we are informed, show a marked steepness at the separation sizes and, stressing the point he wishes to make, all curves plotted for any given separator belong to a family peculiar to that separator. Knowing the Tromp curve of the separator and the grading curve of the raw sand, the grading curve for each of the two separated fractions may be deduced.

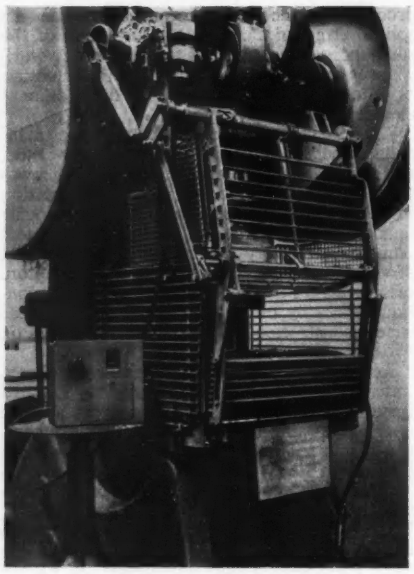
The "Rheax" separators were developed by the Austrian engineer Dr. Theodore Eder and arose out of separation problems encountered in the kaolin industry, but have since found application on a number of civil engineering schemes.

Automatic Control Device for Press Operation

THE press shown in the accompanying illustration is fitted with a guard and control equipment with which the sequence of guard closing, press stroking and guard opening is automatic. When such a machine is equipped for automatic work ejection the operator's duties are reduced to simply feeding blanks to the die when the guard opens. In the event of the operator's hands obstructing the closing of the guard, the guard falls back after a short delay and the press stroke is automatically cancelled. This "Auto-Trip" guard equipment is made by Press Guards, Ltd., 372, Farm Street, Birmingham, 19, and it works in conjunction with an interlocking guard which, when it reaches the fully closed position, actuates a pneumatic valve to trip the press clutch; at the top of the press return stroke the guard automatically re-opens. The control mechanism of the new device can be set to give any required number of operating cycles over a useful range.

In the illustration the control cabinet can be seen on a stand on the left-hand side of the machine, but, if more convenient, it can be mounted on the press itself or on an adjacent wall or pillar. The mechanism is driven by a small geared electric motor and is connected through an air line to the press guard cylinder.

The speed of the electric motor is controlled by a rotary resistance from a knob on the cabinet in accordance with the required press cycle.



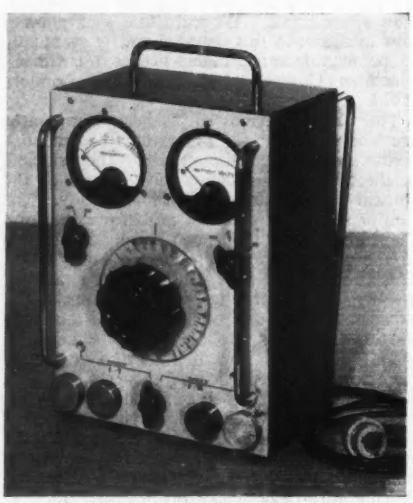
Press fitted with interlocking press guard and control device giving an automatic guard closing, press stroking, and guard opening cycle

The motor drives a cam which, at each revolution, opens a pilot valve controlling the main air supply valve of the guard-closing cylinder. This cam incorporates an adjustable disc member which can be set to give the necessary period of valve opening to meet the speed of press operation. When the equipment is used on slow-running presses the setting of the cam angle can be so arranged that the guard will not open until a predetermined time after the press has come to rest.

The makers point out that, although cam adjustments can be made relatively quickly, two alternative forms of controllers have been developed for installation where users prefer not to have to make cam angle adjustments when varying cycle times. In these controllers there are two separate circuits, one for setting the valve open time and the other for the remainder of the press cycle time.

Portable Metal Sorter and Resistivity Test Set

WE illustrate a portable, battery-operated instrument, made by the Solartron Electronic Group, Ltd., Thames Ditton, Surrey, for the sorting and identification of non-ferrous metals and alloys. With this instrument identification of metals is carried out by measuring their resistivities. As illustrated here, the equipment consists of an investigating head or probe plugged into a small instrument case which is, in effect, a resistivity meter.



Battery-operated portable instrument designed for sorting metals by measuring their resistivity. With two ranges it covers resistivities from 1 to 28 microhms per centimetre cube

When the test head is brought near the metal, its inductance changes and the oscillator in the instrument case ceases to oscillate. The calibrated dial is then rotated until the oscillator comes into action again. This point is indicated by the left-hand meter, and the reading of the calibrated dial then is the resistivity of the metal in microhms per centimetre cube. The resistivities of any metals or alloys between 1·0 to 28·0 microhms per centimetre cube can be measured, and, by inference, the metal or metals can be distinguished or sorted.

Typical applications of this instrument suggested by the manufacturer are the inspection of uniformity of cladding or coating; the identification of the clad side of metal, and the detection of inclusions, surface flaws or local variations in hardness or thickness. It is stated that the only limits to the size and shape of the metal to be examined are determined by the following minimum requirements:—The surface must be sensibly smooth, but need not be flat, and the test portion should have a minimum diameter of 0·75in and a minimum thickness of 0·02in.

The operating range of the instrument is covered by two scales (1 to 7 and 5 to 28 microhms per centimetre cube), each with a separate socket to take the plug connected to the lead from the test head.

Two calibration controls and standard metal samples are fitted on the front panel, one for each operational range. Periodic testing of the h.t., l.t. and grid-bias batteries can be done with a four-position switch and the right-hand meter on the front panel of the instrument. A reject mark on the meter dial indicates the point at which batteries should be replaced. The instrument weighs 3 lb, including dry batteries, and it measures 9½in by 7in by 4in.

Low Temperature Welding

A NEW factory has been opened at Feltham, Middlesex, by Eutectic Welding Alloys Company, Ltd., for the production of its low-heat-input welding equipment and accessories. Facilities have been included in the factory for training engineers in the use of the company's products. On the occasion of a recent visit we were given a demonstration of some of the low-temperature welding alloys and processes. The welding alloys are supplied either as welding rods, each with its companion flux, or as electrodes with "Frigid Arc" coatings, which utilise the surface alloying properties of the base metals, at temperatures below those of fusion, during the welding process. It is claimed that with the use of these special rods and fluxes, providing that correct welding procedure is followed, the harmful effects on certain classes of work resulting from the use of the higher temperatures required in conventional welding processes, can be minimised. Bonding with these low-temperature welding filler metals is obtained with little or no fusion of the surface of the parent metal, thus lessening the risk of warping, distortion and embrittlement.

Particular attention was drawn to "Xyron 2-25," an electrode specially designed for the welding of cast iron. It is a smooth-flowing, non-spattering electrode, is without porosity and is easily machined. Also demonstrated was the "Chamfertrode," a metal working electrode for gouging or grooving all metals with electric arc.

The manufacturers pointed out that although suitable for most welding tasks, the processes and equipment demonstrated are particularly suitable for maintenance and repair work.

STEEL ROLL DOORS.—Golmet, Ltd., of Virginia Park, Caerphilly, announces an addition to its range of roller shutters. The curtain of the door, of corrugated and riveted single sheets, is spring-loaded and runs in steel channels on nylon washers: it is electro-zinc coated. Two standard sizes of the door, which is fire-proof and rust-proof, are available, namely, 7ft or 8ft wide by 6ft 8in high.

Industrial and Labour Notes

Unemployment and Short Time Working

When Parliament reassembled on January 22, the Minister of Labour, Mr. Iain Macleod, answered several questions about unemployment and short time working. He said that on December 10, the latest date for which figures were available, there were 297,000 workers registered as unemployed in Great Britain, of whom 29,000 were temporarily stopped.

In the week ended January 19, the Minister continued, there were reported to be 130,000 workers on short time, of whom, it was estimated, about 70,000 were affected by the restrictions on oil and petrol supplies. Redundancies affecting about 14,000 workers had also been attributed to these restrictions. The Minister went on to say that a seasonal increase in the numbers unemployed was usual in the early part of the year, and that some additional unemployment was likely to arise this year from the shortage of oil and petrol. The Minister added, however, that he could not estimate how many workers or which industries would be affected.

Referring specifically to the motor vehicle and accessories industries, Mr. Macleod said that 4400 workers were registered as wholly unemployed on December 10. A fortnight ago, 57,000 were reported as being on short time. It was not possible, the Minister explained, to determine the precise effect of the various factors causing unemployment, or to make any estimate for the future, but most of the current short time was attributed to the shortage of petrol. Comparable figures for a year previously were 1500 unemployed and about 7000 on short time.

Export Trends

In its *Bulletin for Industry*, the information division of the Treasury comments on export trends during last year. It says that, in 1956, British manufacturing industry exported a larger share of its output than in 1955, or indeed than in any of the three years 1953–1955. The 1956 proportion (excluding food, drink and tobacco) was about 30 per cent, compared with 28 per cent in the two preceding years, and 29 per cent in 1953. The *Bulletin* explains that the share of output which went abroad rose last year because, while manufacturing industry's total output did not go up at all, the volume of manufactures exported increased 6 per cent.

The *Bulletin* goes on to point out that, each year since 1953, the share of engineering products in the total of Britain's exports has risen, and the share of textiles has fallen. In 1956, for the first time, engineering provided 40 per cent and textiles less than 10 per cent of Britain's exports. An analysis of the engineering exports indicates that from 1953 to 1954 it was the rise in road vehicle exports which was mainly responsible for the overall increase. Then, from 1954 to 1955, the share of road vehicles declined a little, and the increase came from machinery. From 1955 to 1956, the road vehicle share dropped further, there was some increase in machinery exports, and there were big increases in exports of aircraft and ships. It was these two classes which caused the proportion of engineering products in total exports to rise more quickly in 1956 than in either of the two preceding years.

As to the "area pattern," the *Bulletin* says that the sterling area's share of United Kingdom exports rose from 1953 to 1954 and has since fallen—particularly fast in 1956. But the converse is true of the dollar area's share; it fell from 1953 to 1954 and has since risen, particularly quickly in 1956. The share of exports going to O.E.E.C. countries has changed little; it fell in 1955 and rose again last year. But the share of our exports going to the rest of the world has risen, largely because Soviet Eastern Europe has been taking more.

Royal Ordnance Factories

On Monday, in the House of Commons, various questions were put to the Minister of Supply, Mr. Aubrey Jones, about the future of the Royal Ordnance factories. In particular, he was asked what plans had been made for the changeover to the production of civil goods, in the light of the declining needs of the services and the improving prospects of international agreement on disarmament.

The Minister said that the Royal Ordnance factories at present undertook civil work on a limited scale as suppliers to other industrial organisations. Although they might take on more work on that basis when it was convenient and economical to do so, there were no plans for changing over the factories to the manufacture of civil goods on a large scale. The Minister went on to say he agreed that, in view of a likely reduction in the arms programme, it was desirable to undertake a review of the whole Royal Ordnance capacity, and that was being done. But he submitted that to go into civil work on a large scale would be inconsistent with the conception of the factories as primarily munitions factories.

Steel Demand

This week the annual report of John Summers and Sons, Ltd., has been issued. It is accompanied by a statement from the chairman, Mr. R. F. Summers, who says that towards the end of the financial year (September 29, 1956) there were signs that the restrictions on hire purchase, and the credit squeeze, were adversely affecting a number of steel consumers. The position was further complicated by the fact that there were still substantial quantities of sheets being imported by some of the consuming industries under contracts placed before the slowing up in home consumption. These imports in 1956, Mr. Summers observes, amounted to approximately 200,000 tons, with the result that, at the moment, the stocks of sheets in the hands of consumers are substantially above normal. It may be, the statement continues, that during the period of acute shortage the estimates of requirements were somewhat exaggerated. But Mr. Summers suggests that the increase in stocks and the fall in demand indicate that "the most difficult period might lie immediately ahead."

Mr. Summers goes on to say that the recession in the demand for steel sheets brings up the question of the future policy of the steel industry. There have been many statements made, he comments, as to the likely total future demand for steel in this country; but the question now is whether these are, in fact, reliable, both as to the total quantity and the dates by which such quantities will be required. The demand for sheets, the statement continues, is bound to increase throughout the world so long as the standard of living is on the upgrade, because such a large quantity of sheet steel is used by the industries providing articles which make life easier and more pleasant. But, Mr. Summers goes on, these are the very articles which are largely controlled by political and economic expediencies; if the balance of payments is going the wrong way, one of the corrective measures is to control the consumption of consumer goods in the home market, either by the tightening up of hire purchase arrangements, by higher purchase tax, or by a credit squeeze, or by a combination of all three. Nevertheless, Mr. Summers thinks, it is safe to assume that these setbacks, by their very nature, must be of a temporary character, and the rise in the standard of living throughout the world will continue.

Mr. Summers then expresses the view that the happenings of the last twelve months have shown that the original estimate of the speed at which expansion will take place has been exaggerated. He thinks that the ultimate figures mentioned for steel demand may very well be achieved, but he expects the achievement to come somewhat later than it was originally thought. If that assumption is correct, Mr. Summers says, it could turn out as a blessing in disguise, as he thinks there has always been some doubt as to whether, in fact, it would have been possible for the steel industry to have reached its envisaged output in the comparatively short time available.

Railway Wages

At the end of last week it was stated that the National Union of Railwaymen had rejected a wage increase offer made by the British Transport Commission. Originally, the N.U.R. submitted a claim for a 10 per cent wage increase for its members employed on British Railways. After negotiation, the British Transport Commission offered 3 per cent, an amount which was unacceptable to the N.U.R. That offer was amended last week by the Commission, which said that it was prepared to make wage increases which would, on the average, represent a rise of about 3½ per cent on existing rates. The N.U.R., it has been announced, will now submit its case for a 10 per cent increase to arbitration. It will be recalled that another railway union, the Associated Society of Locomotive Engineers and Firemen, has already accepted a 3 per cent wage increase for footplate men.

Teaching Production Engineering in Universities

Last April, a conference of university professors was held at Delft to discuss the teaching of production engineering at university level. This conference was initiated by the Institution of Production Engineers and a full report of the proceedings of the conference has now been published by the Institution. It is emphasised that the report refers specifically to the education of production engineers within universities, and that it is not intended to conflict in any way with the proposals made in the White Paper on technical education.

The conference included delegations from the United Kingdom, the Netherlands, Belgium, Switzerland and Western Germany. The report ends with some recommendations which were made by the United Kingdom delegates. Among them is a suggestion that there should be further development of university schemes in Britain to provide integrated courses involving not less than twelve months' guided and approved workshop practice; approximately three years' basic engineering study at university level, if possible with some bias towards the principles of production engineering in the latter stages, followed by one full year or more devoted to the special subjects of production engineering. It is also urged that industry should give all the assistance it can to further the development of such schemes, and, in particular, to see that the industrial aspect is adequately supported by the collaboration of specialists whom industry alone can supply. Finally, it is recommended in the report that "full professional recognition be given on the successful completion of such an approved university course taken as a whole or as an acceptable combination of undergraduate, post-graduate, and industrial components."

Supersonic Airliner Projected

The Ministry of Supply has announced that it, in conjunction with the aircraft industry and the national airline corporations, has embarked on a research project with a view to the possible development of a supersonic airliner. Seven companies are concerned: Avro, the Bristol Aeroplane Company, de Havilland, Handley Page, Rolls-Royce, Short Brothers and Harland, and Vickers-Armstrongs. Once a design has been settled on, the Ministry will issue a contract for its design and production to one of these companies, the others probably being utilised as sub-contractors. The Royal Aircraft Establishment at Farnborough will take part in the preliminary research work. If this venture does proceed beyond the project stage, it is expected to take at least ten years to materialise. No details have been disclosed of the studies in hand but it is expected that a swept plan form, allowing a subsonic aerofoil section, would be employed. An airliner capable of flying from New York to London at a Mach number of 1·8 would be able to make two return journeys every twenty-four hours, double the utilisation of the Mach 0·8 machines at present under construction.

Exhibits at the Chemical, Rubber and Plastics Exhibition, Paris

By F. F. JARAY, Dr. Eng. (Vienna), M.I.Chem.E.

WE briefly referred to the Fourth Salon de la Chimie in our article of December 14, 1956, page 863. In what follows we mention a few exhibits which may be taken as typical of the modern trend of thought in France.

Pinch valves are nothing substantially new, but in the past their rubber diaphragms have tended to fail prematurely, especially when the valves were used for severe duties. Dosapro has developed a pneumatically operated pinch valve (Fig. 1). In a steel body a rubber sleeve is housed and fastened to both ends of the main casing with two flanges which exert a positive grip. The rubber is reinforced in such a manner

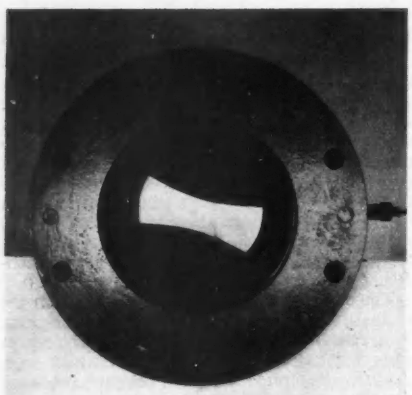


Fig. 1—Pinch valve in half-open position

that folding and collapse will be along predetermined lines, thus ensuring positive closing even with rough material such as concrete. Operating pressure is approximately 20 lb above the pressure of the liquid. By choosing sleeves from suitable elastomers it is possible to handle a large variety of materials and chemicals.

For a considerable time the same firm has been building metering pumps with pneumatic control of output. From this a pneumatic servo-device has been developed. A small electric motor rotates a shaft on which are arranged a number of cams; these cams in their turn operate small air valves which control the pressure for the pinch valves or on the control mechanism of the metering pumps. In this way the operation of ion exchange plant, for instance, can be made a completely automatic process, which can be started after a certain quantity of liquid has been treated and assures the regeneration, flushing and restarting of the installation.

A diaphragm pump for pumping comparatively small quantities of chemically aggressive material was shown by Pelletier. This was constructed entirely from "Teflon" (polytetrafluoroethylene), a material which is completely unaffected by practically all the known chemicals. Output could be controlled simply by turning a knob, thus changing the amplitude of the stroke by moving a cam.

A chemically resistant pump, of course, requires chemically resistant tubing, and polytetrafluoroethylene tubing was shown by a number of companies, including Cicra. This firm has also developed a very simple method of joining pipes made from this material, a problem which has proved rather difficult until now. The joint is made with a plastic sleeve housed in a stainless steel tube, a tapering spiral, also of plastic. It is used as packing for the gland on either side. The chemical handled would therefore be exposed throughout to polytetrafluoroethylene without encountering materials of lesser chemical resistance. Cicra also showed a new design of plug valve, the spindle of which was supported by a polytetrafluoroethylene diaphragm, which was secured in the housing. This valve avoids leaking glands even if the plug is damaged, and is said to remain tight under all conditions.

Among the heat exchangers shown, one of the most interesting appeared to be the "Polybloc," made in France by Carbone-Lorraine and in this country under licence by Robert Jenkins and Co., Ltd., Rotherham (Figs. 2 and 3). The heat exchanging element is a cylindrical block of approximately 1ft diameter and 4in height. It carries two sets of passages, the length and diameter of which are arranged in such a manner that extremely high turbulence is achieved. As a consequence heat exchange coefficients are very high; no scaling up has been observed in three or four years' working even with most difficult liquids like, for instance, pickle liquor from steel pickling plant. The "Polybloc" is a typical unit construction and practically any heat transfer area can be obtained simply by assembling the requisite number of blocks. There are no cemented joints which, as practice has shown, are always a potential source of trouble. An American heat exchanger, the "Holoflite," was shown, which has two hollow screws running against each other and moving doughs or powders from the entrance to the exit. Steam or heating fluids can flow through the screws so that every particle of the powder is exposed to the hot surfaces and dried.

A novel design of centrifuge by Lumpp attracted attention (Fig. 4). The basket is

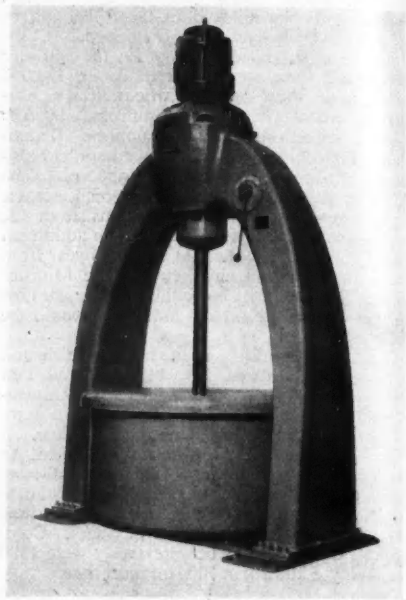


Fig. 4—Variable-speed centrifuge

arranged at the bottom end of a fairly long shaft, which is only supported at its upper end on an arch-shaped frame. The driving motor is arranged on the top and a mercury contactor on the shaft cuts out the motor when a certain predetermined number of revolutions per minute is reached, and switches on again when the speed has sunk by a small percentage. In this way the centrifuge can be used economically over a large range of speeds. As the two bottom ends of the arch are flexibly mounted on the base, the whole system can swing round its axis of inertia. If the amplitude of this movement becomes too large the motor is cut out automatically and a brake stops the centrifuge within a few seconds. Discharge is arranged downward, thus eliminating all complicated and expensive unloading.

Breguet showed a high-pressure vertical

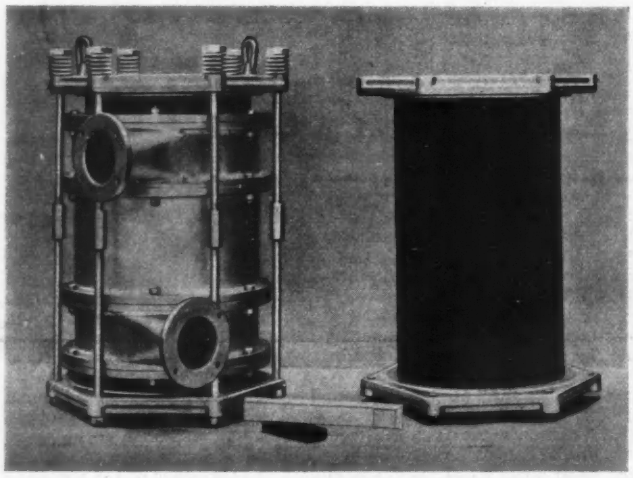


Fig. 2—Graphite block heat exchanger, (left) complete exchanger, (right) stack of graphite blocks

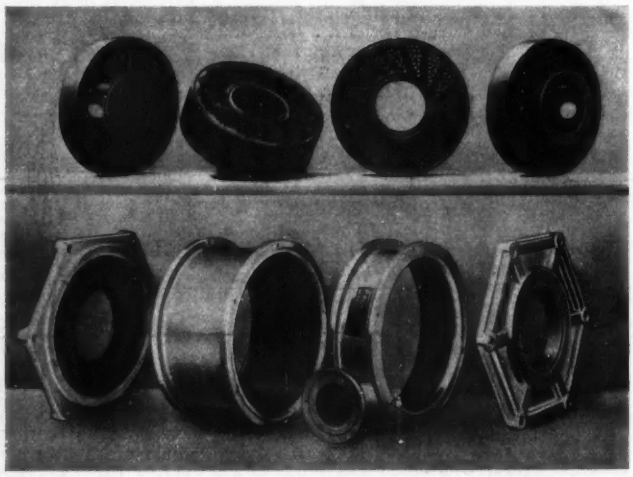


Fig. 3—Components of graphite block heat exchanger, (top) graphite elements, (bottom) casing elements

circulating pump without stuffing-box. The main use of the pump is the forced circulation in La Mont boilers and similar equipment. The pump is separated from the directly coupled electric motor by a heat barrier consisting of a cored block of steel, through which circulates a small bled-off quantity of cooling water, which the pump passes through a heat exchanger. At the bottom and inside the casing of the electric motor is a small impeller, which receives water through the heat exchanger and pushes it upwards to act as lubricant for the motor bearings. The water then re-enters the pump.

Fibre glass reinforced plastics were much in evidence, though quite obviously much of it was still in the development state. Nor-Fru overcame the difficulties connected with simultaneously subjecting glass fibre laminates to temperature, liquid and stress by using the laminate as a lining material for steel vessels. So far these vessels, used in the paper industry, have stood the test of time for about two years. Even a steam-jacketed pan was exhibited.

A variable-pitch propeller, the blades of which were made solidly from "Rilsan" polyamide (a "Nylon" plastic) was shown by Organico. The blade length was 65cm, and it was stated that ten such propellers have already been in use for a few years, mainly with Danish fishing boats. They are outstanding on account of their small weight, their great resistance to erosion and cavitation and resistance to mechanical shock, which is especially important to fishing boats operating in ice-covered waters.

Mobility of Labour in Western Europe

One of the aims of the European Coal and Steel Community is to remove the barriers standing in the way of free movement of coal and steel throughout its six countries. But in addition to this, the High Authority is empowered to press for elimination of those barriers which still prevent workers from moving to the job of their choice, regardless of national frontiers. On May 26, 1954, the High Authority signed a pact with the governments of the six member states of the Community, to provide skilled coal and steel workers with a European Labour Passport. In addition, government experts are currently discussing a multilateral agreement to ensure that workers shall suffer no loss of social security benefits by migrating to other Community countries.

Large numbers of workers within the Community are already employed in countries other than their own. Almost all Community countries are stated to employ in their coal and steel industries immigrant workers from other parts of the Community. As an example, their distribution in Belgium is given in the table below :—

Belgium	Coal mines*		Steel industry†	
	31.3.55	31.12.55	31.12.54	31.12.55
Germans	2,028	1,924	21	26
Belgians	94,770	90,139	40,015	41,628
Frenchmen	1,408	1,338	473	485
Saarlanders	6	1	1	1
Italians	38,926	47,445	4,851	5,508
Luxemburgers...	51	48	123	117
Dutchmen	3,177	2,992	152	153
Citizens of non-European territories of member countries	1,313	1,768	8	11
Other nationalities... ...	10,924	11,930	1,362	1,472
Total...	152,603	157,585	47,006	49,401

* Workers, apprentices, employees, technicians and staff.
† Workers, excluding apprentices.

Nevertheless, the European worker is traditionally less mobile than his American cousin. In Europe some observers consider labour mobility as a last resort to avoid unemployment, but others believe that, in the best conditions, it can be a means of opening up new regions and thereby enriching Europe as a whole. In any case, a certain degree of mobility is at once a consequence and a cause of economic progress ; it can, moreover, be a means of harmonising and increasing both wages and professional skill. As a means of improving productivity in the Community, it is particularly important, therefore, to create not only a common market in goods, but also a common market in labour. For the worker mobility is one means of insuring continuity of employment and of softening the impact of technical and economic progress.

In order to have at its disposal a full picture of the factors which make for and against the free movement of labour within the six countries, the High Authority decided to conduct an investigation into the matter. In May, 1954, the Common Assembly requested the High Authority to make a particular study of the working and living conditions of the Community's migrant workers. As a result five research institutes* were instructed to produce national reports on the whole problem. On the basis of these findings, the High Authority, with the collaboration of the UNESCO Institute of Social Sciences, Cologne, published a summary report with numerous appendices, as a preliminary to detailed studies of the problems involved. The report offers no general formulæ for successful labour transfers, but states that each situation requires a separate solution. Above all, it stresses the need for an approach to the individual. Each worker must feel that it is his personal decision to move. Special individual needs must be watched, such as schooling for the migrant's children and the possibility that aged parents may have to accompany him and be accommodated. The question of compensation must be carefully handled. Every move entails expense not only at the time of moving but also afterwards, and in all successful schemes these additional expenses have been covered. The question of waiting allowances, separation allowances for men who temporarily have to leave their wives behind, and of payment of one or two months' additional salary must be considered.

The candidates for transfer must be selected with the greatest care, the report continues. They must be considered not only from the technical but also from the psychological standpoint. A remarkable feature of many readaptation schemes, it is stated, has been the liability of a few men of strong personality but psychologically unsuited to adaptation to new circumstances to disaffect large numbers of their fellow migrants.

Not only must the individual candidate be judiciously selected, but the group from which he comes must be conditioned in such a way that a pressure of ill-informed opinion against the transfers is not built up. Here it is important that the group should be adequately provided with the facts, and that strong emphasis should be placed on the worker's freedom to make his own decision on whether or not he will transfer. Each worker considered for the transfer should be individually briefed. He should receive full and comprehensible information, notably on the economic reasons for his displacement and the likely deterioration in standards of workers generally unless a substantial number of them moves. Transport arrangements, compensation plans, the measures adopted to solve resettlement problems, and the migrant's future prospects, both at his new job and as an inhabitant of the area to which he is moving, should be fully explained. It is important that no illusions should be created ; all the advantages and disadvantages of the worker's old place of work and of the place to which he is moving should be fully presented. The worker will want to know about wages, cost of living, the type and conditions of work he is going to and his future in the industry.

The first moves are the critical ones. It is essential that they should be a success, since reports on them will be going back to other prospective migrants as the first arrivals write home to their friends. Hence the need for detailed planning well before the transfer operation starts.

It is not, however, merely a question of moving the workers and getting them to stay : they must fit in by adapting themselves to their new job and their new surroundings. The first stage of assimilation is that of getting used to their new conditions of living and working without breaking the links with the old. A whole series of difficulties may occur and lead to friction with the local population. The sex life of single migrants is a frequent cause of local discontent. Wives of migrants often find it difficult to adapt themselves to their new surroundings. Children are the most adaptable of human beings. But they also present a problem, that of their education. Are they to have separate schools or classes ? The High Authority suggests that they should learn their mother tongue but should not be kept separate from the local children.

Since housing plays a major role not only in the decision to move but also in adaptation afterwards, the general shortage of housing has been a main stumbling block in transfer schemes.

Adaptation must start at the factory. If the workers are to settle down in their new surroundings there must be good relations between existing workers and the new arrivals. Even in the case of a transfer within the same country, new arrivals are sometimes surprised at the difference of atmosphere between their old place of work and the new. Where a worker changes not only his domicile but also his country and type of employment the difficulties are multiplied. In such cases it is essential that good reception measures for the new arrivals should be introduced, especially when these come into industry from agricultural or handicraft work.

* Sozialforschungsstelle an der Universität Münster, Dortmund, Institut de Sociologie de l'Université de Liège, Institut National d'Etudes Démographiques, Paris, Istituto di Scienze Economiche presso l'Università del Sacro Cuore, Milan, and Nederlands Instituut voor Praeventieve Geneeskunde, Leiden.

Magnetic Dynamic Gramophone Pick-Up

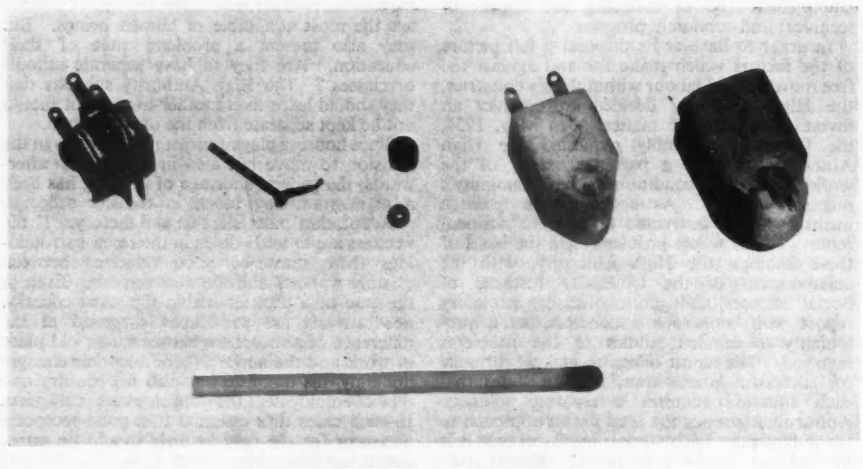
Besides the piezo-electric gramophone pick-up, which is the most popular design for general use to-day, use is often made for professional purposes of the electro-dynamic system, which employs a light coil actuated by the needle and moving in the field of a strong permanent magnet. A magneto-dynamic design, in which the needle rotates a transversely magnetised rod situated in the air gap of a soft-iron yoke provided with windings, has been developed by Philips Research Laboratories, Eindhoven, and is shortly to be placed on the market. It is made with either a sapphire needle for standard 78 r.p.m. discs, or a diamond needle for micro-grooves. Electric response to needle movement is stated to be very nearly linear, with a sensitivity of about 4mV per centimetre per second, which is considerably better than that of an electro-dynamic but less than that of a piezo-electric pick-up. The required vertical force on the needle is about 10 g, to prevent it leaving the track and to give minimum wear. Our illustration shows the yoke on the left, next to it the assembly of magnet rod, needle arm and needle, the two supporting bushes, the coil encased in polyester resin, and the complete assembly. The scale is indicated by the match.

The illustration shows the comparative simplicity of the design, which is stated to be robust and completely proof against tropical climatic conditions.

The magnet rod is magnetised in the direction of the needle arm so that when the needle is trailing in an unmodulated groove the flux to both poles of the yoke is the same and none passes through the coils. When, however, the needle arm is deflected by a small angle, magnetic symmetry is upset and magnetic flux passes through the coils in one direction or the other. Any change in this flux produces an induced voltage in the coils, the value of the voltage being proportional to the rate of displacement of the needle, and its frequency, to the number of vibrations per second which the needle carries out.

Requirements with regard to the magnet which are fulfilled in the present design include a small moment of inertia about the axis (in view of the large accelerations which occur), and retention of their magnetisation. The latter requirement is important because the magnet has to be replaced together with the needle when the needle is worn out ; it must not be possible for spare magnets to become demagnetised by contact with iron parts or tools or by the action of stray fields, e.g. from transformers.

As a thin rod magnetised at right angles to its axis has a high demagnetisation factor, this design became feasible only by using a material with a high coercive force. Such a material is "Ferroxdure," which has a coercive force of about 80kA per metre (about 1000 Oersted), compared with about 50kA per metre for "Ticonal" steel. It also has a low density,



Magneto-dynamic pick-up (right) and components

about 4 g per cubic centimetre, as compared with 7 g per cubic centimetre for "Ticonal," a fact which contributes to a low moment of inertia.

The rods are manufactured by extrusion, followed by sintering and subsequent centreless grinding. A compromise has to be found between a small mass and a large magnetic flux. In the present instance, a diameter of 1mm was chosen, with an effective length of 8mm and a total length of 12mm, giving a weight of about 40 mg and a flux of 0·7μV second. The effective equivalent mass at the needle point—which determines the inertia forces—is, however, only 3 mg. The attraction between an iron turntable and a magnet of such a small size is quite negligible compared with the minimum force with which the needle must rest on the record in order not to jump the groove. This is stated to constitute one of the great advantages of the magneto-dynamic system over the electro-dynamic system.

The needle arm has to communicate, without distortion or loss, the lateral movement of the needle due to the modulation of the record. A vertical movement, the so-called "pinch-effect," arises from the fact that the wave-shaped groove is narrower at the flanks than at the peaks, giving a different depth of engagement with the rounded needle point. This vertical movement must not be transmitted, i.e. the arm must be thin. In order that lateral needle movement be transmitted accurately, the natural frequency of the arm must be higher than the highest frequency which is to be reproduced, for above the point of resonance almost all the movement of the needle is absorbed by deflection of the arm, resulting in a large drop in output voltage. The natural frequency in the present case is above 25 kc/s. Since the force on the needle acts below the point of support of the arm, a twisting couple is set up which tends to cause torsional oscillation; the resonance frequency of these oscillations must also be kept above the highest frequency one wishes to reproduce; here its value is about 25 kc/s. It is not possible to increase torsional stiffness, and thus the torsional resonance frequency, by making the arm thick, without at the same time transmitting pinch-effect vibrations to the magnet rod. These vibrations, at twice the frequency of modulation, are reproduced because of the (small) "vertical response" of the pick-up which arises from inevitable inaccuracies in manufacture. If, on the contrary, the needle arm is made flexible, vertical response in the range above about 1000 c/s, for which the pinch-effect is important, can be reduced. At the same time, while still sufficiently stiff to support the vertical needle pressure, the needle arm can flex back so that if the pick-up is accidentally dropped on the disc, the weight of the head is taken on two shoulders formed on the housing.

The magnet and the needle are fixed to the arm by aluminium cleats, thus avoiding the need for extreme accuracy in the diameters of the holes. The radius of curvature of a sapphire needle is 75 microns, while diamond needles have a 25 micron radius.

The magnet assembly is supported by means of two bushes which are seated in recesses in the polyester moulding in which the coil unit is encased. The top bush, which clamps the magnet, is of rubber and supplies the necessary restoring couple. The lower bush is made of P.V.C. and provides the required damping, while giving only a small restoring couple. The complete unit is mounted inside a soft-iron casing provided with earth terminal, to give combined magnetic and electrostatic screening, and is surrounded by a housing of "Philite." The yoke is also earthed to obviate the effects of static electricity caused by the friction between needle and record.

Flameproof Transformer for Coal Mines

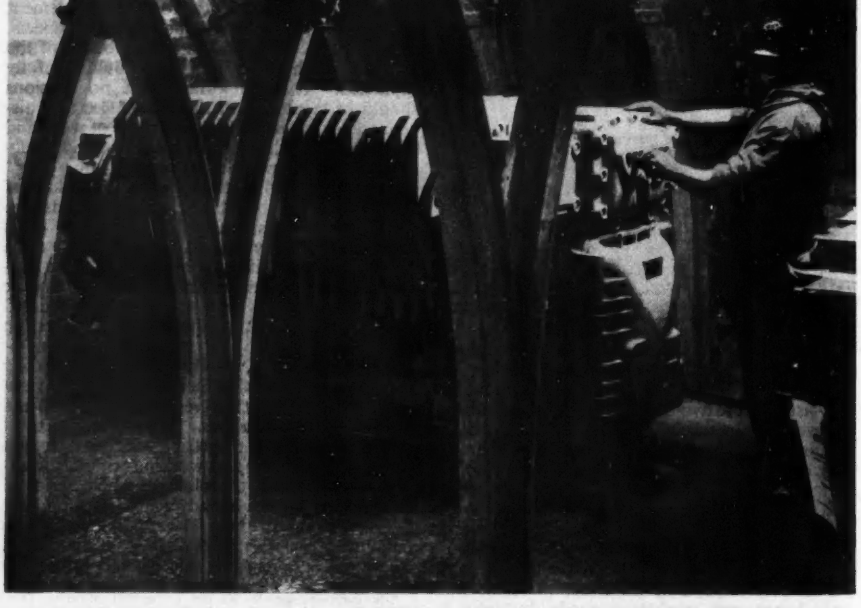
For many years, flameproof transformers for underground use have been built by ACEC (Ateliers de Constructions Electriques de Charleroi, Charleroi, Belgium). Constructed for use in Class III mines (firedamp), these transformers have to comply with the safety requirements issued in 1927 by the "Institut National des Mines de Belgique," and in certain instances have to be easily movable so that they can follow the coal face. Although the earlier designs were giving satisfactory service, the fact that they were oil-filled always constituted a certain fire hazard. Even the use of incombustible liquids for the cooling of transformers is not without risk. Such liquids as are known at present are either themselves toxic or decompose into toxic gases under the action of an electric arc. Any leakage or electric damage could therefore be very dangerous in a mine gallery.

These were the main considerations which have led ACEC to develop the air-cooled transformer, made entirely from non-combustible materials. The illustration below shows such a transformer, the first of twenty of 500kVA capacity supplied to the Helchteren Zolder collieries. It is claimed for this design that maintenance costs are reduced to a minimum, dismantling for checking and repairs is facilitated, and that the equipment is very mobile and has a high overload capacity.

The transformer tank is of oval section. It is built from steel sheet of sufficient thickness to withstand internal explosion test pressures without permanent distortion. Convection is increased by cooling tubes and fins, so that frame temperatures do not exceed 50 deg. Cent. above the ambient temperature. An anti-explosion drain valve allows the removal of condensed water. Access to the transformer is gained by removing the bolted-on explosion-proof end sections. The transformer ratio may be varied by off-load changes of the connections which are housed behind an explosion-proof panel. All insulation is based on silicone varnishes, used in conjunction with glass fibre or mineral fillers. Such insulation has a life of seven years at 220 deg. Cent., the rate of deterioration doubling with every 12 deg. Cent. rise in temperature. Grain-oriented laminations are used in the magnetic cores, more than halving the iron losses.

Steel Production in the Saar

During last year production of the Saar region's iron and steel works has further increased and for the first time surpassed a figure of 3,000,000 tons of crude iron. Compared with an output of iron of 2,878,000 tons in 1955, that of last year was 3,031,000 tons, an increase of 5·3 per cent. Crude steel production during the same period rose to 3,349,000 tons in 1956, compared with 3,144,000 tons in the preceding year, an increase of 6·6 per cent. Even greater was the rate of expansion of the rolling mills (2,718,000 tons in 1956, compared with 2,428,000 tons in 1955).



One of Belgium's first air-cooled explosion-proof transformers of 500kVA for the Helchteren Zolder coal mines

The American Scene

BY OUR AMERICAN EDITOR

National Automobile Show

A PANORAMA of the American way of life of to-morrow was on view in New York during December. It was on wheels, of course. It was two-or-more-toned. It was power-steered, power-braked and power-air conditioned. It was wide and long, chromium plated and low slung, equipped with pneumatic springs and push-button control. It was, in fact, 124 examples of American 1957 motor-cars, all to be seen and dreamed over at the New York Coliseum during the recent National Automobile Show. This was the first time in sixteen years that these artifacts of the native culture have made their collective début in New York, and the contrast between their present and former display quarters is symbolic. When the now solid, almost antique motor vehicles of 1940 took their bow their habitat was the old Grand Central Palace, which presents quite a striking contrast from the audacious new Coliseum. The 1956 exhibition had a theme, "America on the Move." To symbolise this, a monumental outline of an automobile 16ft high and weighing 2 tons, occupied a dominating position on the second floor. The passenger cars on view were being shown by the appropriate divisions of General Motors, Chrysler, Ford, American Motors and Studebaker-Packard. They offered a wide selection, ranging from stately saloons and dashing sports cars to two-door vehicles with special appeal to smaller purses. Vying in popular interest with the automobiles themselves was the enormous, almost futuristic, character of "technical improvements" embodied in the new models. Vehicles were adorned with four headlights. They were fitted with six-barrel carburetters, new fuel injection devices, the smaller, 14in wheels and tyres, torsion bar suspension, air cushion suspension and the non-slip differential. The variations in the four-headlight system included dual mounting, either horizontally or vertically of the headlamps in each front fender. The six-barrel carburetter was designed to provide smooth, economical power and to help raise engine ratings by about 25 h.p. Two barrels function at normal cruising speeds, and the four additional barrels commence to operate when additional acceleration is required. An improved fuel injection system was designed to feed fuel-air mixture to each of the cylinders in a new measure of precision and even distribution, supposedly bringing engine efficiency to a new peak. The gamut of novelties was a wide one, each contributing to the looks and ways of the 1957 cars. Fourteen inch wheels and tyres have facilitated the lowering of the car silhouette and changes in design which gave that "lower, longer look." Torsion bar suspension replaces front coil springs in some cars. Air cushion rear suspension consists of a rubber mounting in the shape of a 6in by 1½in miniature tyre, inserted between the frame and the rear spring. A non-slip differential divides the power between the rear wheels so that needed traction is transmitted to the wheel when required, for example, when snow, icy or slippery roads are encountered or when a wheel is embedded in mud or soft shoulders. Among the other 1957 innovations are electrically operated door locks, power-vented windows, power-operated seats with six-way motions, recessed safety door handles, emergency brakes operated with foot pedals, and push-button automatic car lubrication. A supercharger is being offered for the first time in standard American car production, as is a variable front coil springing that adjusts to varying loads throughout the spring range. Included among the new safety devices are a buzzer, which sounds an alarm when a predetermined speed is reached, and an optional item consisting of a child's safety jacket that doubles as a safety belt.

The American automobile industry lives in the future. The Coliseum in December last was filled with this year's automobiles. The laboratories and design offices in the automobile factories are filled now with dreams and even bluprints for cars that will be on the highways five years or more from now. In order to place the developments in the new 1957 automobiles in the proper historical perspective against their sixty-odd years of the immediate past, and the immediate and imaginative future, it would seem appropriate to quote from a recent glimpse into the future by Mr. Harlow H. Curtice, the president of the General Motors Corporation. "We are confident our customers will want automobiles in greater quantity and representing even greater value for their money. In 1955 the number of persons per automobile in the United States was 3·2, and by 1980 the ratio is likely to be 2·5 persons per motor-car. As for future styling, we believe that in all probability the 1966 models will be no longer, wider or higher than they are to-day. The shape of these vehicles will depend a great deal on engineering developments, some of which may be in the making to-day. For instance, General Motors engineers are experimenting with both gas turbine and free piston turbine engines, and at the same time are steadily improving and refining the piston engine. It is impossible now to predict which of these three engines will predominate in the next decade. Meanwhile, we are certain that 1966 engines will be lighter and more efficient than anything we are using to-day, because we are learning more about lighter metals, improved design and better fuels. The lighter and more abundant metals, aluminium or magnesium, probably will be used more than they are to-day in both the engine and body structures of automobiles principally because metallurgists anticipate a time when we may have to slow the depletion of iron ore reserves. Possibly also the rigid, resilient and flexible plastics will find more automotive uses. We do not have enough experience with plastics yet, but technology in the plastics industry is improving so rapidly that I am sure 1966 models will contain more of those materials than the 1957 models."

The motor car is the backbone of America's industrial civilisation. Automobiles are integrated into the basic structure of all manufacturing, mining, agriculture and trade. One-quarter of the country's steel goes into automobiles, two-thirds of all rubber, one-fifth of the nickel and three-quarters of the aluminium castings. In the United States to-day five out of six skilled and semi-skilled workers own their own cars. Two out of three white-collar workers, clerks and salesmen are in the car owner group. So are five out of six farm operators. Even among unskilled and service workers nearly half are able to afford cars. The vehicles they own may be shiny 1957 models with two years of instalment payments hanging over the owner's head. Or they may be "jalopies" long past due at the junk yard. But they are yardsticks of a standard of living that is as much a part of America as the Grand Canyon or the Mississippi River.

Penetration and Diffusion of Gamma-Rays

During several years of intensive research, the National Bureau of Standards has developed systematic methods for solving many of the radiation penetration problems associated with nuclear power and propulsion reactors, radiation fall-out and medical uses of radiation. Starting on a small scale in 1948, *the programme has rapidly broadened as advances in theory and computational technique have extended the range of problems that could be treated. To a large extent, the programme is co-ordinated with those of other governmental and private institutions concerned with radiation, and close liaison is maintained, for example, with the Shielding Group at the Oak Ridge National Laboratory and with the Federal Civil Defence Administration.*

SINCE 1948 an increasing amount of research and development work has been conducted at the National Bureau of Standards, Washington, D.C., aiming at a solution of radiation penetration problems associated with nuclear power and propulsion reactors, radiation fall-out and medical uses of radiation. Although concerned with ionising radiations of all kinds, the programme thus far has dealt principally with gamma-rays. The study as a whole is under the direction of the N.B.S. Nuclear Physics Section, and is supported by the U.S. Atomic Energy Commission, the Office of Naval Research, the U.S. Navy Bureau of Ships, and the National Bureau of Standards. So far, major attention has been given to gamma-ray photons in the energy range of 0·1MeV to 10MeV, which is of primary interest in shielding problems. While most of the work has dealt with mathematical theory and computational methods, a number of experiments have been performed, partly to verify the calculations and partly to provide suggestions for fruitful theoretical approaches. Also, the available experimental data on the subject were collected, analysed and tabulated in order to provide input data for the calculations.

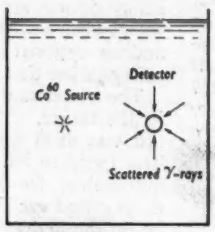
In the study of propagation in infinite uniform media, L. V. Spencer and U. Fano have developed the method of polynomial fitting by moments for calculating the penetration of gamma-rays to moderate depths, while the problems of deeper penetration have been clarified by the theoretical researches of U. Fano. These results are adaptable to automatic computation and with them pilot and large-scale calculations have been carried out for a wide variety of special problems. In many of these calculations, the Bureau has worked in close collaboration with Nuclear Development Associates, Incorporated, of White Plains, New York. The problems were calculated on "SEAC," the N.B.S. automatic computer, using codes prepared by the Bureau's

computation laboratory. Recently the more difficult problems of penetration in non-uniform media and, in particular, the effects near a boundary between two different media, have been studied with considerable success. Both theoretical analysis and Monte Carlo experiments with automatic computers have been used. More and more attention, also, is being given to research on the penetration and diffusion of high-energy electrons and neutrons. It has been found that many of the methods developed for gamma-rays can be adapted to these other forms of radiation as well.

The General Problem

Given a distribution of radiation sources within a material, the general problem of penetration is to determine the intensity and spectrum of the radiation that flows in each direction at each point of the material. It might seem that practical penetration problems, such as shielding design, could be solved experimentally with the help of a radiation source, several thicknesses of absorbent materials, and a radiation detector. In the past this has often been attempted, but it proved necessary to perform large-scale experiments of an engineering character whose results could not be extrapolated to different conditions. The difficulties arise because the manner of propagation of radiation depends on so many variable factors—the different kinds of interaction with the medium, the energy spectrum and directional distribution of the radiation, and the density, atomic weight and geometry of the medium. When gamma-ray photons traverse a medium, any of several different "elementary" processes may take place. A photon may be absorbed completely, its energy being used to eject an electron from an atom (photo-electric effect); a part of the energy of the photon may be used to eject an electron, while the photon goes off in a new direction with diminished energy (Compton scattering); or the photon, if its energy is greater than 1MeV, may disappear, to be replaced by an electron-positron pair. These three elementary processes are the dominating factors in the propagation of gamma-rays in the range of 0·1MeV to 10MeV. At the lower end of the range, a minor contribution from Rayleigh scattering must be taken into account. At photon energies above 15MeV, neutrons may be ejected from nuclei; and at energies above 150MeV, photons begin to interact with intra-nuclear fields, giving rise to mesons in a process analogous to pair-production.

The total effect of all processes that either absorb photons outright or that deflect them from their original paths, is measured in the so-called "narrow-beam" experiment. As shown in Fig. 1, a source of mono-energetic gamma-rays is channelled by slits in heavy shielding into a narrow parallel beam which passes through a layer of absorbing material to a gamma-ray detector. The beam must be narrow enough to prevent once-scattered photons from reaching the detector, and the absorbing layer must be sufficiently thin so that there is practically no chance that photons deflected out of the beam will be deflected back to the detector by further interactions. The graph reproduced shows that, for a given absorber thickness, photons from the broad beam lose relatively less of their original intensity. The build-up factor (ratio of actual intensity to that which narrow-beam attenuation would produce alone) can be read off directly from a semi-logarithmic graph such as this. Fig. 2 shows schematically an experiment and graph comparing experimentally measured build-up factors in three media with values computed by the National Bureau of Standards, using the moment method. The experimental data were obtained by the National Bureau of Standards and by the Canadian National Research Council in collaboration with Nuclear Development Associates, Incorporated. Under the conditions of the narrow-beam experiment the probability p that a photon will penetrate a distance x follows an exponential law: $p = exp(-\mu x)$, where μ, the "attenuation coefficient," is the probability that an interaction will occur in traversing unit distance. The smaller the value of μ, the greater is the penetrating power of the radiation. The distance $1/\mu$ can be interpreted as the mean free path of a photon, i.e. the average distance travelled between interactions.



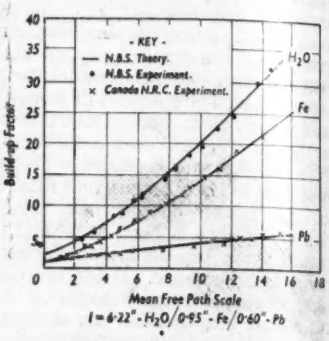


Fig. 2—Diagrammatic arrangement of experiment and resulting graph comparing experimentally measured build-up factors in three media with computed values

Using the simple exponentional law, one can calculate how much of the primary radiation reaches a given point directly from the source. In addition to this, however, "secondary" radiation is also present. This consists largely of photons that have been scattered several times, arriving by a roundabout route; photons emitted by atoms from which electrons have been ejected (fluorescence); X-rays (bremsstrahlung) produced when ejected electrons are slowed down by the medium; and annihilation radiation produced when positrons recombine with electrons. To calculate the contribution of secondaries to the radiation at a given point, data are needed on the probabilities of the various possible elementary and secondary processes. Such data are available, at least to the extent needed for shielding problems; they are obtained either from experiments or from quantum-theoretical calculations. In any case, the solution to a specific problem is often expressed in terms of the "build-up factor," which is simply the ratio of the total radiation intensity to the intensity due to primary radiation alone, as calculated from narrow-beam data. To cope with the tremendous mathematical difficulties of combining these many different probabilities, each of which varies with the energy of the photon and the nature of the medium, simplifying assumptions must be made. The aim is to choose these assumptions so that realistic problems can be approximated by a combination of several simplified cases. A mono-energetic source and an infinite homogeneous medium are perhaps the most obvious of such assumptions. The source is also assumed to have one or the other of four simplified geometries: point-collimated, with radiation from a single point in a single direction; point-isotropic, with uniform radiation in all directions from a single point; plane-collimated, with radiation emitted perpendicularly to the plane; or plane-isotropic, with uniform radiation in all directions from each point of a plane. The point-collimated or "gun" source is both the most fundamental and the most difficult to compute; the first numerical results for such sources have only recently been obtained. Also, instead of studying the radiation flow at each point of the medium, one may try to find average or integrated values of the distribution—for example, the spectrum of secondaries integrated over the whole medium, or the distribution-in-direction of gamma-rays degraded to a certain energy level regardless of their position with respect to the sources.

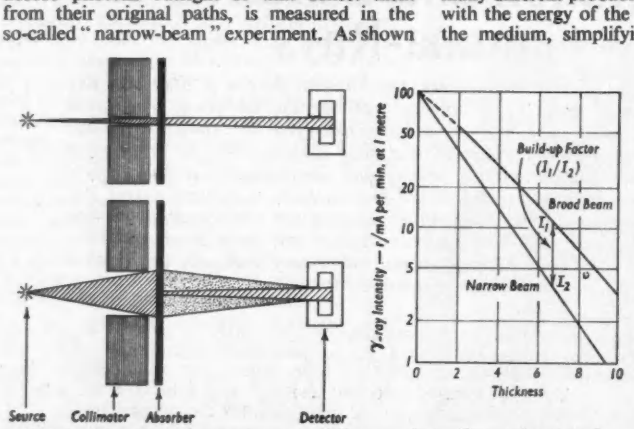


Fig. 1—Diagrammatic arrangement of "narrow beam" experiment and graph of gamma-ray intensity on a base of absorber thickness

Moderate Penetration

A large proportion of the detailed information now available on gamma-ray penetration has been obtained from calculation based, directly or indirectly, on the polynomial method. The labour required in calculating by this method the photon density and spectral and angular distributions is approximately the same for all depths up to ten to fifteen mean free paths. After that the effort increases roughly as the cube of the depth, so that the method is unsuitable for great depths. For practical purposes, however, a depth of twelve mean free paths, for example, is fairly large, since in that distance the primary radiation loses all but one part in about 160,000 of its original intensity. The method is therefore suitable for nearly all shielding problems. Well adapted for use with high-speed automatic computers, the polynomial method is a semi-numerical technique for solving the Boltzmann transport equation for an infinite medium. The original equation is reduced to a set of integral equations for the space moments of the photon density with energy as the whole independent variable. These equations are so inter-related that the successive space moments can be calculated by numerical integration of a finite number of the equations without any need for analytical approximations. The final solution can then be expressed in terms of the space moments and certain polynomial systems.

In one formulation, for example, the build-up factor for the density of photons of given energy and direction at a given depth is expressed as an infinite series in which each term is the product of three factors: a "weighted obliquity parameter," which depends on the space moments and the given data; a Laguerre polynomial with argument $\mu x/\rho$, where ρ is the density of the medium; and a Legendre polynomial with the cosine of the direction angle as argument. Any desired degree of accuracy can be obtained by evaluating the series out to a sufficient number of terms. This, however, requires that a corresponding number of moments be calculated first. In practice, only a few of the moments are needed for results of relatively high accuracy. The method has been applied by Nuclear Development Associates and the Bureau in an extensive calculational programme on the penetration of gamma-rays in materials throughout the periodic table and for point-isotropic and plane-collimated sources. The materials investigated include pure Compton scatterer, water, aluminium, iron, tin, tungsten, lead and uranium. Recently, pilot calculations were started for a gun source; and among others, a calculation is now under way for plane-isotropic sources, which will provide data of direct use in radiation fall-out problems. The raw results of the calculations are in the form of the weighted obliquity parameters mentioned above. These are calculated separately for different materials, source geometrics, and source energies, and are tabulated for a series of secondary photon energies. Solutions to specific problems are then obtained by combining the appropriate raw data and tabulated values of the required polynomials.

Deep Penetration

In the study of penetration to depths greater than those accessible to the polynomial method,

the Bureau's research work has led to a number of mathematical laws and workable methods of calculation. Such investigations are not only indispensable for the treatment of unusually severe shielding problems, but they are useful for increasing the confidence in numerical methods whose reliability tends to decrease as the depth of penetration increases. Analysis shows that the intensity and spectral distribution of radiation at great distances from the source depends in a crucial way on whether the primary photons are above or below a certain energy, E_m, at which the narrow beam absorption coefficient for the given scattering medium has a minimum. That such a minimum exists for each medium has been known for some time. As the energy of primary photons is raised, the absorption coefficient fails steadily to a minimum at E_m and then rises again. Photons with energy, E_m, are thus more penetrating than those with either more or less energy. In the case of lead, for example, the energy of the most penetrating radiation is 3·4MeV. The values of E_m for a number of media are tabulated here.

Element	E_m(MeV)	Element	E_m(MeV
4Be	94	20Ca	13
5B	70	26Fe	9
6C	56	30Zn	7·6
7N	46	40Zr	5·4
8O	39	48Cd	4·4
9F	33	56Ba	3·9
10Ne	29	74W	3·5
13Al	21	82Pb	3·4
		92U	3·3

The energy of a secondary photon cannot, of course, exceed that of the primary photon which gave rise to it. In fact, with the minor exception of those due to Rayleigh scattering, photons originating from interactions with the medium have energies less than those of the primary radiation. Hence, as radiation penetrates farther into a medium, the secondary photons fall to lower and lower energy levels. If the energy of the primary photons is less than E_m, it means that the secondaries become less and less penetrating and their intensity decreases faster and faster. On the other hand, if the energy of the primaries is greater than E_m, the secondaries will gradually increase in penetrating power until their energy falls to E_m. After reaching the value E_m, the energy of secondary photons will continue to fall as a result of further interactions. However, since photons of energy E_m have the maximum penetrating power, their further degradation in energy takes place more slowly. As a result, photons become partially "trapped" in the spectral region just below E_m, and the relative intensity of that part of the energy spectrum tends to increase.

Theoretical analysis indicates that at great depths the distribution in energy and direction of photons substantially below E_m in energy tends to become stabilised. Consequently, the proportion of secondary radiation with a given energy or moving in a given direction approaches constancy. For primary energies below E_m, the intensity of total radiation at great depths has been found to approximate a law given by the product of an exponential and a power function of the depth.

When the primary energy is above E_m, the manner in which the spectral distribution changes at great depths depends on the steady accumulation of secondaries with energies just below E_m. Those secondaries that are considerably below E_m will have a spectral distribution similar to that which occurs when the primaries are below E_m. Their intensity level, however, depends on the rate at which photons escape from the accumulation near E_m. The intensity of the total radiation under these conditions again follows a trend given by the product of power and exponential functions of the depth. In this case, however, the exponent of the exponential is non-linear. Such functions have been worked out for a number of source geometries. A Fourier-Laplace transform method for the detailed numerical calculation of gamma-ray intensities from plane sources or point isotropic sources which makes use of the mathematical laws mentioned has been developed through the pilot stage. This technique has the advantage that the effort required does not increase rapidly with increasing depth of penetration.

Fig. 3—Apparatus for the experimental study of the propagation of gamma-rays in steel wool near a boundary with steel

Monte Carlo Experiments

Besides the methods described, much use has been made of Monte Carlo experiments. Essentially mathematical rather than physical, this recently developed computational technique makes use of a numerical analogue of the situation under study. In the present programme, these "experiments" have served to take the place of difficult physical measurements, check results of other methods, and study problems for which other methods were not available. They have been the principal method of attack on the study of radiation in the neighbourhood of boundaries between different media. Though employing advanced refinements of numerical technique, the Monte Carlo experiment is, in principle, at least, a straightforward approach. As applied to penetration problems, it calculates the separate histories of a number of photons with the help of chance devices analogous to roulette wheels. A photon is assumed to start with given energy and direction. A chance device, in which the probabilities of the possible outcomes correspond to the probabilities of the possible elementary interactions, is used to decide which of these processes occurs. If a Compton scattering is indicated, for example, another chance device is needed to decide the amount of deflection and energy loss; and it is necessary also to follow in the same way the course of the photon emitted when the excited atom returns to a lower energy state. The process is continued until all the energy of the initial photon is dissipated. If a sufficiently large number of such individual histories is compiled, statistical analysis will then yield the desired information about intensities and distributions

By taking advantage of certain theoretical considerations, the number of "case histories" needed has been reduced to within reasonable limits. Even so, the use of such a method is greatly facilitated by high speed computers in which the functions of the chance devices may be performed by random or pseudo-random numbers. In seven Monte Carlo problems coded for "SEAC" last year, for example, the computer circuits had to generate many millions of pseudo-random numbers. Many problems have now been calculated by the method and the experience gained has suggested improvements in general coding technique, leading to a greatly increased speed of computation. A special effort has been made to make the data processing automatic, while at the same time permitting examination of the data at any stage of the operation.

Some of the problems that have been treated by the Monte Carlo method have technical applications in the field of reactor design, e.g. the penetration of beams of gamma radiation through shielding walls. Other problems are of radiological interest, e.g. the determination of the radiation dose delivered to various parts of the human body by an ingested gamma-ray source. Still other problems find applications in civil defence activities, e.g. the calculation of the radiation dose received by a man standing on the ground from a gamma-ray source overhead in the atmosphere. A physical experiment related to this problem is also in progress. In this experiment the air-ground complex is replaced by a steel wool-steel complex. This substitution makes it possible to obtain measurements with precision under laboratory conditions instead of in large-scale field tests.

Fig. 3 shows the apparatus developed for the experimental study by the National Bureau of Standards of the propagation of gamma-rays in steel wool near a boundary with steel. The steel-wool mass in the background is approximately 7·5ft by 7·5ft by 15ft and rests on a plate of steel 2in thick. Radioactive cobalt is placed successively at various heights within the steel wool and the radiation intensity is measured at other positions with a scintillation detector. The detector is inserted into one of several pipes running lengthwise through the steel-wool mass. The experiment provides a check on the Monte Carlo calculations of radiation behaviour near boundaries between different media. By taking account of the density ratios it is to some extent possible to extrapolate the present experiment to different media. Thus, information can be obtained about radiation intensities near the ground produced by much larger sources at heights up to about 1000ft in the atmosphere. In extrapolating to denser media, on the other hand, the experiment tells something about radiation intensities very close to the dividing boundary; the scale amplification achieved is suggested by the relative mean free paths of a photon in steel wool of about 2·5ft and in lead of about 0·5in. The detector head consists of an anthracene crystal, a photo-multiplier, and a pre-amplifier. A cable carries the pre-amplifier output to further amplifiers and integrating circuits.

Further Research

As mentioned above, the gamma-ray studies are part of a larger programme whose aim is to acquire a firm knowledge of the phenomena that accompany the passage of ionising radiations of all kinds through matter and of the elementary processes of interaction involved in these phenomena. Much work has already been done on the problems of electron penetration relating to energies up to 40MeV. Calculations based on the moment method have been made and promising new theoretical results have been obtained. All of these activities are to be continued; a "mass production" of computational result is now available, and an application of the moment method to neutron penetration is contemplated.

Further calculations by the moment method are planned on gamma-ray propagation. These will be primarily for gun sources and, possibly, for media with plane boundaries. The Monte Carlo calculations will continue, especially in the study of boundary effects. Tentative work on cascade shower calculations has been started; an early opportunity will be sought to continue this important project. Finally, an effort will be made to extend the propagation studies to higher energy levels and to study elementary interactions with many-particle systems.

Personal and Business

Appointments

MR. H. W. HEMBRY has been appointed a full-time member of the National Coal Board.

ADMIRAL SIR WILLIAM G. ANDREWES has been appointed a director of John I. Thornycroft and Co., Ltd.

MR. M. F. H. S. CHAPMAN has been appointed a director of the Associated Portland Cement Manufacturers, Ltd.

MR. R. A. GRIERSON, M.I.E.E., has been appointed manager of the transformer division of Brush Electrical Engineering Company, Ltd.

MR. FRANK CLARK has been appointed manager of the sales technical service department at Cricklewood of British Oxygen Gases, Ltd.

THE SOUTH WESTERN ELECTRICITY BOARD has announced the appointment of Mr. Peter Murray Wilson, M.I.E.E., as chief engineer.

SAUNDERS-ROE, Ltd., announces that Mr. T. L. Ciastula, Dipl.-Ing., has been appointed chief designer of the company's helicopter division.

THE PLESSEY COMPANY, Ltd., states that Mr. Bruce Wilkinson has joined the company as divisional manager of the Swindon components division.

Q.V.F., Ltd., announces that Mr. Philip Jaram has joined the company as manager at its new premises in Duke Street, Fenton, Stoke-on-Trent.

MR. NEVILLE A. GASS has been appointed chairman of the British Petroleum Company, Ltd., in succession to Mr. Basil R. Jackson, who has resigned for health reasons.

MR. ALEC WALTER STONES has been appointed manager of the western district of British Oxygen Gases, Ltd., Birchgrove, Cardiff, in succession to Mr. J. E. Clark.

MR. K. W. TREVATT has been appointed to represent the Cambridge Instrument Company, Ltd., in the Liverpool area in succession to Mr. W. J. Cole, who has retired.

MR. BASIL BLACKWELL has been appointed assistant chief engineer of Bristol Aero-Engines, Ltd., and will supervise the company's activities in the field of mechanical sciences.

MR. S. F. STEWARD has been appointed chairman of Lancashire Dynamo Holdings, Ltd., in succession to the Rt. Hon. Sir Percy H. Mills, who has been appointed Minister of Power.

METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., has announced that Mr. H. F. Bibby, A.M.I.E.E., A.M.I.Mech.E., and Mr. G. H. Jolley, M.I.Mech.E., have been appointed directors.

Mr. JAMES FLOOD has been appointed to represent the Association of Supervising Electrical Engineers on the National Inspection Council and the National Inspection Board in succession to Mr. E. J. Sutton.

AIR COMMODORE F. R. BANKS, M.I.Mech.E., F.R.Ae.S., has been named as a 1956 honorary fellow of the American Institute of the Aeronautical Sciences, in recognition of his outstanding contributions to aviation.

REAR-ADMIRAL W. H. SELBY has been appointed resident representative in Helsinki of the Federation of British Industries and of its subsidiary company, British Overseas Fairs, Ltd., for the British Trade Fair and Exhibition to be held there in September.

H. LEVERTON AND CO., Ltd., has announced the appointment of Mr. S. Glover as general parts manager of the Leeds depot. Mr. L. F. Everard, parts and service director, has left this country for Chicago to attend the American Road Show and to visit the Caterpillar Tractor Company.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION has announced the appointment of Captain E. W. Lewis, a senior nautical surveyor, in the consultative branch of the marine survey service, as principal officer of the Bristol Channel district, Cardiff. He succeeds Captain J. A. Theyer, who is retiring from the department.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., announces the following appointments:—Dr. R. Beeching, technical director; Dr. J. Ferguson, research director; Mr. L. H. Williams, director in charge of group "B" dyestuffs and pharmaceuticals, in succession to Mr. P. K. Standring, who retires on April 1; Mr. C. M. Wright, development director; Mr. J. L. S. Steel, economic planning director, and Mr. C. Paine, director group "A" heavy chemicals.

LONDON TRANSPORT has announced the following appointments upon the retirement of Mr. L. Bicheno, divisional engineer, central road services, south west division:—Mr. A. E. Butler, divisional engineer, central road services, will be transferred from the south east division to the south west division; Mr. W. I. Kirshner has been appointed divisional engineer, central road services, south east division, and becomes an officer on the executive; Mr. R. D. Gillanders, A.M.I.Mech.E., has been appointed divisional engineer (general) and becomes an officer on the executive.

Business Announcements

MR. H. B. ELLIOTT, service manager of A.C.V. Sales, Ltd., is touring Australasia.

LEO COMPUTERS, Ltd., states that it has moved to Minerva Road, North Acton, London, N.W.10 (telephone, Elgar 2895).

CHEMIDUS PLASTICS, Ltd., states that its administrative and sales office has moved to Dominion Buildings, South Place, London, E.C.2 (telephone Monarch 0131).

BORAX CONSOLIDATED, Ltd., states that it has acquired research laboratories at Tolworth, Surrey, which will provide facilities for a staff of fifty chemists or more.

METALASTIK, Ltd., states that it has concluded an exclusive manufacturing and sales agreement for its products with Carl Freudenberg, K.G., Weinheim, Germany.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., has announced that Mr. T. A. Simpson, deputy general manager, has retired.

MR. A. E. CARRODUS, sales director of Petters, Ltd., has left this country to visit the company's representatives in Thailand, Malaya, Australia, New Zealand, Canada and America.

MR. L. REEVES, M.I.Mech.E., M.I.Loco.E., carriage and wagon engineer of the Eastern and North Eastern Regions, British Railways, has retired, having completed forty-nine years' service.

SIR HUGH BEAVER has resigned from the Council for Scientific and Industrial Research on his appointment as deputy president of the Federation of British Industries. He had served on the council for four years.

THE BALDWIN INSTRUMENT COMPANY, Ltd., announces that it has inaugurated a fluid power division to control the sales and development of pneumatic and hydraulic equipment. Mr. D. A. Larner, A.M.I.Mech.E., is to head the new division.

THE SHIPBUILDING CONFERENCE announces that Mr. Alexander Belch, who has been associated with the employers national organisations in the shipbuilding, ship repairing and marine engineering industries for over forty years, has retired from his appointment as Controller.

MR. GORDON JACKSON, director and general manager of Chaseside Engineering Company, Ltd., and Mr. G. Leskine, development manager, are visiting America to attend the Road Builders Association Equipment Show, Chicago. Mr. Jackson will also visit the subsidiary company, Chaseside Equipment Company of Canada, Ltd., Toronto.

LITHGOWS, Ltd., has announced the formation of a new company, known as Lithgow Power Development Company, Ltd., for the research, development and improvement of marine propulsion and industrial engines. The new company has obtained a licence from Alan Muntz and Co., Ltd., for the manufacture by the associated companies of Pescara free-piston gasifiers. The directors of the company are Mr. T. Abell, Mr. A. W. Davis, Mr. James Ferrier, Dr. T. Scott Glover and Sir William Lithgow.

Contracts

MATTHEW HALL AND CO., Ltd., has been awarded a contract for the major construction of off-site facilities at the "Shell" Refining and Marketing Company's refinery at Shell Haven. The value of this contract is approximately £330,000.

LITHGOWS, Ltd., has received an order from the Crest Shipping Company, Ltd., for a cargo ship of about 11,300 tons deadweight, with free piston/exhaust gas turbine machinery of 7000 s.h.p. The free piston gasifiers will be supplied by the Free Piston Engine Company, Ltd., and the turbine will be manufactured by Rankin and Blackmore, Ltd.

TRANSOCEANIC MARINE, Inc., New York, agents of the Niarchos group of companies, announced that Mr. Stavros Niarchos had placed an order for an oil tanker of 106,500 tons deadweight, to be built at the Bethlehem Steel Company's Quincy Shipyard. The ship will have a length of 940ft by 134ft beam by 49ft draught loaded and be propelled at a speed of 18 knots by two sets of turbines of 43,000 s.h.p.

MITCHELL ENGINEERING, Ltd., has received a £500,000 order from the Central Electricity Authority for the installation of coal handling plant at the Authority's new power station at High Marnham, Nottinghamshire. The plant will include belt conveyors, screening and crushing plant, travelling bunker dischargers, a travelling boom stacker, and a side-discharge weighing wagon tippler.

Miscellanea

SCIENTIFIC INSTRUMENTS DISPLAY.—The fourth exhibition of instruments organised by the Scientific Instrument Manufacturers' Association was recently opened at "Sima" House, 20, Queen Anne Street, London, W.1, and will continue for three months. Sixteen member firms of the Association are exhibiting.

STEEL-CUTTING CARBIDE TOOLS.—In the article, "Steel-Cutting Carbide Tools," in our issue of January 18 last, it was stated incorrectly that the new grades of "Wimet" steel-cutting tools were known as "XL 12" and "XL 13." These grades are, in fact, known as "XL2" and "XL3" and they are to be followed in due course by grades "XL1," "XL4" and "XL5."

INDUSTRIAL AND FACTORY LAW.—The Industrial Welfare Society is holding a lecture course on industrial and factory law, on February 5, 6 and 7, at Robert Hyde House, 48, Bryanston Square, London, W.1. The lectures, which are to be given by Mr. Harry Samuels, Barrister-at-Law, will cover the legal groundwork necessary to industrial managers and executives.

IRON AND STEEL EXPORTS.—The Board of Trade has announced that licences are now required for the export to all destinations of all descriptions of pig iron, steel rails, and alloy and non-alloy steel sections, bars and rods. This decision has been made as a result of recommendations by the Iron and Steel Board, to safeguard supplies of steel for the United Kingdom constructional, engineering and shipbuilding industries.

NAVAL CONSTRUCTION IN 1956.—In a reference to H.M.S. "Defence," in the article under the above title published in our issue of January 11, we stated that she was to have engines manufactured by the Wallsend Slipway and Engineering Company, Ltd. That information, though drawn from official sources, was incorrect. The original machinery manufactured by Scotts' Shipbuilding and Engineering Company, Ltd., of Greenock, is being retained.

ELECTRICITY IN AGRICULTURE.—A film entitled "Current Affairs" has just been completed, under the direction of Humphrey Swingler, for the British Electrical Development Association. It depicts most effectively the various applications of electric power to the business of present-day farming, the emphasis being on the requirements of the smaller farm. The film is available for loan, in 35mm and 16mm sizes, from the B.E.D.A., 2, Savoy Hill, London, W.C.2. Its running time is thirty-one minutes.

LEAD DISPOSALS.—The Board of Trade announced in December its intention to seek trade advice about the best way to dispose of lead from its stocks without unduly disturbing the market. These consultations have now been completed. The Board says that it has been decided to sell about 30,000 tons of lead for delivery and pricing over a period of nine months, beginning in March. Some 4000 tons of this will be offered by open competitive tender and the remainder, to which special considerations apply, will be offered back to the original suppliers or their agents. The availability of tender forms for the 4000 tons will be advertised in due course.

STRUCTURAL ALUMINIUM RESEARCH SCHOLARSHIP.—The Institution of Structural Engineers accepted, in 1954, an offer by the Aluminium Development Association of a research scholarship to enable the holder to undertake research on some aspect of the application of aluminium alloys to structures. It is expected that a report of the research work carried out under the first award of the scholarship made in 1954 will be published towards the end of this year. The conditions of this scholarship have recently been revised and it is now open for award every third year for a two-year period, the value of the scholarship being £600 a year. It is the intention of the Institution to make the next award of this scholarship in 1957 with a view to the successful applicant beginning his investigations at the start of the University session in October next. Entries for the scholarship to be awarded this year close on March 31. The scholarship is administered by the Institution and further particulars, together with forms of entry, may be obtained from the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

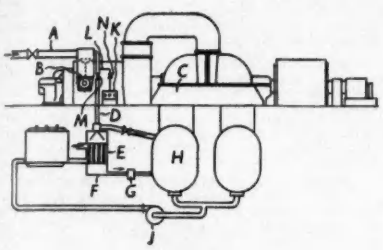
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

STEAM TURBINES

765,223. January 22, 1954.—STEAM TURBINE PLANT, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Reginald George Whitehouse.*)

According to the invention, there is provided a large-capacity steam turbine plant in which means are provided for increasing the rate of steam flow from an incoming steam boiler prior to the restarting of the turbine to produce a rapid increase in the temperature of the steam from the boiler to the turbine to a level substantially of the same order as the temperature level of the steam chest of the turbine. As shown in the drawing, *A* is a pipe along which high-pressure steam from a boiler is suppliable via a stop valve *B* to the turbine *C*. A pipe *D* is connected to pipe *A* for diverting part of the steam to a large quick-starting air ejector *E* provided with a condenser chamber. This condenser chamber is connected by means of a pipe *F* and trap *G* to a main condenser *H* for the turbine so that condensate from the ejector *E* can drain into the main condenser, where it is deaerated and then picked up by extraction pump *J*. The connection *F* between the quick-starting air ejector *E* and the main condenser *H* may



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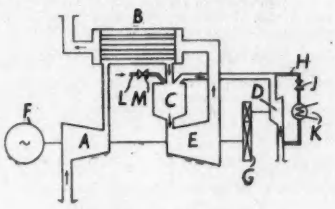
advantageously include a float valve and flash box. When it is desired for the quick-starting air ejector *E* to deal with considerable steam flow it may be necessary for its condensing chamber to be fed with normal cooling water supply as an alternative to the supply of condensate from a surge tank. During the starting of the turbine plant the turbine casing glands may be sealed with steam at or near the temperature obtaining at the stop valve *B*, although it is appreciated that a somewhat lower temperature could be allowed for in the sealing glands without giving rise to distortion. Accordingly, the steam for the sealing glands may be supplied to a gland seal manifold *K* through a conduit *L* fed from pipe *D*. For the purpose of detecting temperature levels at the inner wall of the steam chest and at the stop valve *B*, any convenient apparatus may be used, but it may be convenient to employ thermo-couples. In use it is envisaged that, with a bypass valve *M* open to allow the tapped steam supply from the incoming boiler to the quick-starting ejector *E* and with the tapped steam also delivered to the sealing glands of the steam casings, via valve *N*, then as the steam temperature at the stop valve *B* rises to match the temperature at the steam chest, as may be detected by thermo-couples disposed at the stop valve and at the inner wall of the steam chest respectively the stop valve would accordingly be opened to introduce steam quickly to the turbine to enable it to be brought up to speed and reloaded.—*January* 9, 1957.

GAS TURBINES

765,270. February 23, 1955.—GAS TURBINE PLANTS, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

The invention relates to a method of operating a gas turbine plant which uses a gaseous fuel of low calorific value and in which both the fuel gas and combustion air are compressed before entering a combustion chamber connected in series with the turbine and also embraces gas turbine plants suitable for carrying out the method. In the plant shown in the drawing the combustion air compressor *A* sucks in air from the atmosphere and delivers it under pressure through a preheating heat exchanger *B* into a combustion chamber *C*. The fuel gas compressor *D* sucks in fuel gas of low calorific value, for example, gas from the top of a blast-furnace, and delivers it under pressure into the combustion chamber *C*, where it is burnt. The combustion products from the combustion chamber are expanded in a turbine *E* and then pass away to exhaust through the heat exchanger *B*, in which some of their heat is withdrawn for preheating the incoming air. The compressor *A* and the turbine *E* are mounted on a common shaft, which also drives the load, for instance, an electric generator *F*. The fuel gas compressor *D* is driven from the same shaft through speed-increasing gearing *G*. For control purposes the fuel gas compressor *D* is provided with a return pipe *H* fitted with a control valve *J* and a cooler *K*. Should the supply of fuel gas be reduced, in the event of a blast-furnace being



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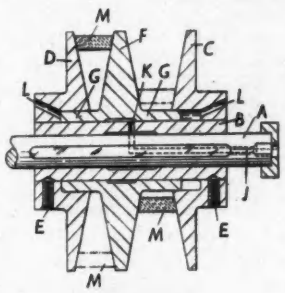
shut down, a fuel of higher calorific value can be introduced into the combustion chamber *C* through a pipe *L* fitted with a control valve *M*. In this event the combustion air compressor *A* must supply a larger volume of air to make up for the reduction in the volume of the fuel gas. This is done through an adjustment of the guide blades of the compressor *D*. The fuel gas compressor *D* can be adapted to suit the reduced supply of fuel gas in a similar manner by a blade adjustment. A section of the combustion air compressor with the adjustment device for the guide blades is also described in the specification.—*January* 9, 1957.

POWER TRANSMISSION

764,844. May 4, 1954.—VARIABLE-SPEED DRIVES, Petrie and McNaught, Ltd., Crawford Street, Rochdale, Lancashire. (*Inventor: Herbert Partington.*)

The invention relates to variable-speed drives having a double vee belt pulley composed of two fixed cones and a movable cone between them. Referring to the drawing, *A* is the shaft carrying the pulley and *B* is a sleeve mounted on the shaft, which has the fixed cones *C* and *D* mounted on it and secured by the grub screws *E*. The movable cone *F* is free to slide on the shaft *B* and it has a boss *G* extend-



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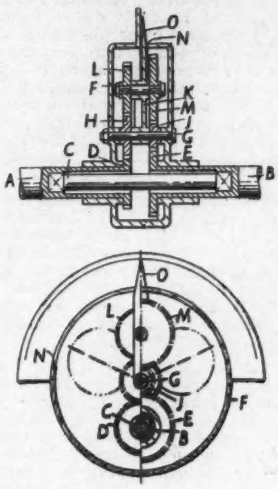
ing at either side. The fixed cones *C* and *D* have recesses, which receive the ends of the boss *G*, the length of which is such that its ends project into the recesses in all positions to prevent tilting of the cone. Lubricant can be introduced through a passage *J* in the shaft *A* and a passage *K* in the sleeve *B*. Vents *L* leading from the recesses to the outer sides of the fixed cones allow air and excess lubricant to escape without coming into contact with the belts *M*.—*January* 2, 1957.

MEASURING INSTRUMENTS

764,977. October 6, 1954.—TORQUE INDICATING OR MEASURING APPARATUS, National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventor: Ulrich Max Willi Barske.*)

As shown in the drawing, the torque to be measured is transmitted by a composite shaft comprising two rigid portions *A* and *B*, which do not twist appreciably under normal loading. They are joined by a torsion bar *C* in which considerable twist occurs under normal loading. Integral with the inner ends of the two rigid shafts are two input wheels *D* and *E* of different diameter. These wheels, together with the shafts are journalled in opposite walls of a casing *F*, within which is supported a bearing shaft *G*. This shaft has journalled on it two sun wheels *H* and *J* and a carrier member *K*, which extends radially beyond a double planet wheel having toothed portions *L* and *M* journalled on it, and passing through and beyond a slot *N* in the casing, where it is shaped as a pointer *O* and moves over a scale on the casing as the carrier member moves angularly about the shaft *G*. The arrangement is such that the movement of the pointer



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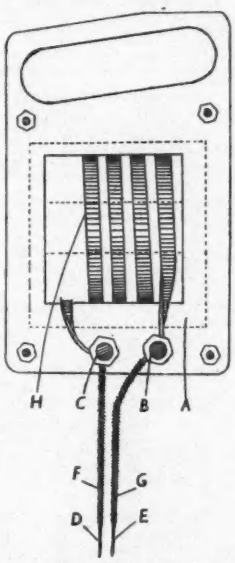
over the scale is proportional to the turning or rotating movement of the shaft portion *B* relative to the shaft portion *A*. In use the pointer *O* is displaced only when the shafts are displaced angularly about the common axis. The scale *P* may readily be calibrated in terms of torque by holding one of the shafts and applying known static torsional loads to the other. A modified mechanism for measuring the twist or torque is also described in the specification.—*January* 2, 1957.

WORKSHOP TOOLS AND APPLIANCES

765,625. March 10, 1955.—SOLDERING APPLIANCES, Richard Herbert Bailey, 116, Summers Lane, Finchley, London, N.12.

The appliance according to the invention consists of a hand tool with a mains transformer incorporated in the body of the tool and with two copper wire soldering "needles," each fitted with a spiral cooling fin or wire and two terminals for connecting the transformer secondary to the "needles." The



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"needles" preferably consist of lengths of bare copper wire, about No. 14 S.W.G., filed to thin tapering points and the points "tinned." In the drawing *A* indicates the mains transformer, *B* and *C* the terminals, *D* and *E* the "needles," *F* and *G* the spiral cooling fins or wires, and *H* the secondary winding. In operation, the "needle" points are placed a little apart on the soldering tag, wire, or like object being soldered, so that it becomes part of the transformer secondary circuit, which delivers 30A to 50A at about 1V. The "needles" are each fitted with the spiral cooling wire or fin to concentrate the heat at the "needle" points.—*January* 9, 1957.

Launches and Trial Trips

ZAPHON, oil tanker; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for Shell Tankers, Ltd.; length between perpendiculars 675ft, breadth moulded 89ft, depth moulded 49ft, draught loaded 36ft, deadweight 38,000 tons, service speed 16¼ knots; thirty-three cargo oil tanks, one main cargo pump room, three 1050 tons per hour cargo oil pumps, three stripping pumps; two 600kW turbine-driven alternators and one 150kW diesel-driven alternator; one set of Wallsend Slipway double reduction geared turbines, 16,500 maximum s.h.p. at 108 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Babcock and Wilcox boilers.—Launch, October 31.

RIVERBANK, open shelter deck cargo liner; built by William Doxford and Sons (Shipbuilders), Ltd., for the Bank Line, Ltd.; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded 29ft 6in, deadweight 10,450 tons; five holds, one 25-ton, four 10-ton, ten 5-ton derricks, electric winches; Doxford oil engine, four cylinders of 700mm diameter by 2320mm combined stroke, 4800 b.h.p.—Launch, December 17.

KINGSTON, collier; built by The Burntisland Shipbuilding Company, Ltd., for the South Eastern Gas Board; length between perpendiculars 261ft 6in, breadth 39ft 5in, depth 18ft 6in, draught loaded 17ft 1in, deadweight 2835 tons; three cargo holds, electric deck machinery; British Polar diesel engine, eight cylinders, 340mm diameter by 570mm stroke, 1150 b.h.p. at 225 r.p.m.—Trial, December.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF MINING ELECTRICAL AND MECHANICAL ENGINEERS

Tues., Feb. 5.—TECHNICAL MEETING: 21, Bloomsbury Street, London, W.C.1, "Routine Maintenance of Electrical Apparatus in Collieries," G. M. Harvey, 6.15 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Feb. 1.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "X-Ray Production and Problems," L. C. Maple, 7.30 p.m.

Mon., Feb. 4.—LEEDS BRANCH: Great Northern Hotel, Leeds, "Ball and Roller Bearings," J. Warren, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "Review of Modern Lighting Techniques," D. E. Mutch, 7.30 p.m.——SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Lighting for Production," J. W. Howell, 7.30 p.m.

Tues., Feb. 5.—LUTON BRANCH: Chamber of Commerce, George Street West, Luton, "General Application of P.F. Control," F. T. Bartho, 8 p.m.——OXFORD, READING AND DISTRICTS BRANCH: University, London Road, Reading, "The 13th Edition of the I.E.E. Rules," J. J. Looker, 7.15 p.m.——W. LONDON BRANCH: Windsor Castle Hotel, 134, King Street, Hammersmith, London, W.6, "Recent Developments in Television," G. E. Partington, 7.30 p.m.

Wed., Feb. 6.—N. LONDON BRANCH: Queen's Head, 677, Green Lanes, Harringay, London, N.4, "Radio Valves," G. H. Gardner, 7.45 p.m.——PRESTON BRANCH: R.A.F.A. Club, East View, Preston, "Industrial Uses of A.C. Capacitors," P. R. Coursey, 7.30 p.m.

Thurs., Feb. 7.—S. LONDON BRANCH: Half Moon Hotel, Broad Green, Croydon, "Fluorescent Lighting: Modern Applications," G. V. McNeill, 8 p.m.

Fri., Feb. 8.—BRISTOL AND W. OF ENGLAND BRANCH: Grand Hotel, Bristol, "High Frequency Heating Application," A. Hogan, 8 p.m.

BELFAST ASSOCIATION OF ENGINEERS

Wed., Feb. 6.—College of Technology, Belfast, "The B.T.H. Project at Larne," D. R. S. Turner, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Feb. 7.—N.W. SECTION: College of Technology, Sackville Street, Manchester, 1, "Electronics in Medicine," R. F. Farr, 6.30 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Feb. 2.—Caxton Hall, Caxton Street, London, S.W.1, "Accelerations in Flight," F. Latham, 6 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Feb. 6.—MIDLAND SECTION: Leofric Hotel, Coventry, "The Smokeless Operation of Boilers and Furnaces on Solid Fuel," C. H. G. Hayward, 10.30 a.m.; "The Smokeless Operation of Boilers and Furnaces on Liquid Fuel," C. A. Roast, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Wed., Feb. 6.—NEWCASTLE UPON TYNE CENTRE: Grey Hall, Department of Electrical Engineering, King's College, College Road, Newcastle upon Tyne, "Lighting for Photography," R. W. Unwin, 6.15 p.m.——SWANSEA GROUP: S. Wales Electricity Board, The Kingsway, Swansea, "Light and its Effect on Plant Growth and Egg Production," A. E. Canham, 6.30 p.m.——EDINBURGH CENTRE: Y.M.C.A., 14, South St. Andrew Street, Edinburgh, "Lighting as an Effective Aid to Architecture," H. E. Bellchambers, R. V. Mills and H. R. Ruff, 6.15 p.m.

Thurs., Feb. 7.—NOTTINGHAM CENTRE: Electricity Service, Centre, Smithy Row, Nottingham, "The Use of Coloured Light," H. Hewitt, 5.30 p.m.——GLASGOW CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Lighting as an Effective Aid to Architecture," R. H. Ruff, R. V. Mills and H. E. Bellchambers, 6.30 p.m.——CARDIFF CENTRE: S.W. Electricity Board, The Hayes, Cardiff, "Architects Approach to Lighting," G. Grenfell Baines, 7 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Feb. 5.—LONDON BRANCH: Royal Society of Arts, John Adam Street, London, W.C.2, "Automation—the Maintenance Aspect," Sir Walter Puckey, 7 p.m.

Thurs., Feb. 7.—PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "Light and Lighting," A. L. Berridge, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 4.—MERSEYSIDE AND N.W. SECTION: Liverpool Engineering Society, The Temple, Dale Street, Liverpool, Annual General Meeting and "Fundamental Principles of Marine Instrumentation," F. P. Prout, 6 p.m.——W. MIDLANDS SECTION: Birmingham Exchange and Engineering Centre Stephenson Place, Birmingham, Annual General Meeting and "Free Piston Engines," P. Watson, 6.45 p.m.

INSTITUTE OF METALS

Thurs., Feb. 7.—LONDON LOCAL SECTION: 17, Belgrave Square, London, S.W.1, "Beryllium," Bengt Kjellgren, 6.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Feb. 6.—26, Portland Place, London, W.1, "Patents in the Petroleum Industry," J. T. Tyson, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Feb. 7.—Junior Institution of Engineers, Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Antibiotics for the Preservation of Perishable Foods," Ella M. Barnes, 5.30 p.m.; and "A Discussion of the Possibilities of Using Ionizing Radiations for Preserving Foods," R. S. Hannan, 5.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Mon., Feb. 4.—WESTERN CENTRE: Electricity House, Bristol, "Economics of Mechanisation of the Small Farm," S. R. Wragg, 7.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Feb. 2.—MIDLANDS BRANCH: Midlands Institute, Paradise Street, Birmingham, Annual General Meeting, 2.30 p.m.; "Automatic Control of Continuous Distillation Plant," E. J. Eaton and R. Parkins, 3 p.m.

Tues., Feb. 5.—The Geological Society, Burlington House, London, W.1, "Liquid-Liquid Extraction," H. R. C. Pratt, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 5.—STRUCTURAL AND BUILDING: Great George Street, Westminster, London, S.W.1, "Large-Span Prestressed Concrete Bridges Constructed by the Freyssinet System," Y. Guyon, 5.30 p.m.

Thurs., Feb. 7.—HULL AND E. RIDING BRANCH: Electricity Showroom, Ferensway, Hull, "Design and Reconstruction of West Pier, Royal Dock, Grimsby," W. M. Sewell and P. H. Jacob, 6.15 p.m.——N.W. ASSOCIATION: Engineers' Club, 17, Albert Square, Manchester, A Vernon-Harcourt Lecture, "British Waterways, 1931–1956," C. M. Marsh, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 4.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, Informal Evening, "The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering," E. C. Cherry, 5.30 p.m.——N.E. RADIO AND MEASUREMENTS GROUP: King's College, Newcastle upon Tyne, "The Measurement of Earth-Loop Resistance," G. F. Tagg, 6.15 p.m.——S. MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, "Technical Development and Training in the U.S.S.R.," G. S. C. Lucas and D. P. Sayers, 6 p.m.——MAIDSTONE DISTRICT MEETING: Maidstone Technical College, Tonbridge Road, Maidstone, "The Potentialities of Railway Electrification at the Standard Frequency," E. L. E. Wheatcroft and H. M. C. Barton, 6.30 p.m.

Tues., Feb. 5.—S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "The Control and Instrumentation of a Nuclear Reactor," A. B. Gillespie, 7 p.m.——E. ANGLIAN SUB-CENTRE: Technical College, Cambridge, "Large Power Transformers," E. T. Norris, 6 p.m.——N. MIDLAND CENTRE: Central Electricity Authority, Yorkshire Division, 1, Whitehall Road, Leeds, "The Crystal Palace Television Transmitting Station," F. C. McLean, 6.30 p.m.——N.W. CENTRE: Engineers' Club, 17, Albert Square, Manchester, "Some Aspects of Heat-Pump Operation, with particular reference to the Shinfield Installation," Miriam V. Griffith, 6.15 p.m.

Wed., Feb. 6.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Place of Liberal Studies in Sandwich and other Technological Courses," opened by E. H. Horrocks, 6 p.m.——S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Control and Instrumentation of a Nuclear Reactor," A. B. Gillespie, 7 p.m.——E. MIDLAND CENTRE: De Montfort Hall, Leicester, "Nuclear Energy in the Service of Man," T. E. Allibone, 7.15 p.m.——SOUTHERN CENTRE: S.E. Electricity Board, 10, Queen's Gardens, Hove, 3, "Developments in Lighting Techniques," L. H. Hubble, 6.30 p.m.

Thurs., Feb. 7.—Savoy Place, London, W.C.2, "The Place of Engineering in University Education," Joint Meeting with the Institutions of Civil and of Mechanical Engineers, 5.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Wed., Feb. 6.—E. MIDLANDS BRANCH: College of Arts and Crafts, Waverley Street, Nottingham, "School Heating," J. H. R. Parris, 6.45 p.m.

Thurs., Feb. 7.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Current Practice in School Heating," L. Oliver, 6 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Feb. 1.—N.E. BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Modern Concrete Road Construction," D. R. Sharp, 7 p.m.

Thurs., Feb. 7.—YORKSHIRE AND LINCOLNSHIRE BRANCH: New Chemistry Lecture Theatre, University of Leeds, "The Use of Mechanical Equipment," C. H. Howitz, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 1.—AUTOMOBILE DIVISION: Dinner and Dance, Dorchester Hotel, London, W.1, 7.30 p.m.

Mon., Feb. 4.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, "The Salvaging of Ships with particular reference to the 'Empress of Canada,'" W. R. Colbeck, 6 p.m.

Tues., Feb. 5.—APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Locking Devices and the Prevention of Loosening of Components," 6.45 p.m.——COVENTRY A.D. CENTRE: Leofric Hotel, Coventry, "A Review of Hydrokinetic Fluid Drives and their Possibilities for the British Motor Industry," J. G. Giles, 7.15 p.m.——N. IRELAND COMMITTEE MEETING: Kensington Hotel, Belfast, "An Investigation into the Mechanism of Oil Loss Past Pistons," P. de K. Dykes, 7 p.m.

Wed., Feb. 6.—SCOTTISH BRANCH: North British Hotel, Princes Street, Edinburgh, "The Salvaging of Ships, with particular reference to the 'Empress of Canada,'" W. R. Colbeck 6.30 p.m.——N.E. GRADUATE SECTION: Newcastle Joint Meeting of the Local Branches of the Institutions of Mechanical, Electrical and Structural Engineers, and of the North East Coast Institution of Shipbuilders and Engineers, 7 p.m.

Thurs., Feb. 7.—JOINT MEETING WITH THE INSTITUTIONS OF CIVIL AND OF ELECTRICAL ENGINEERS: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Place of Engineering in University Education," Sir Ifor Evans, 5.30 p.m.

——EASTERN BRANCH: Good Companions Hotel, Slough, Joint Meeting with Southern Branch, "Fretting Corrosion," R. B. Waterhouse, 7.30 p.m.——Royal College of Science and Technology, George Street, Glasgow, "The Salvaging of Ships, with particular reference to the 'Empress of Canada,'" W. R. Colbeck, 7.30 p.m.——YORKSHIRE GRADUATE SECTION: Mining Lecture Theatre, University, St. George's Square, Sheffield, "Gasworks Engineering," A. Stubbs, 6.30 p.m.

Fri., Feb. 8.—1, Birdcage Walk, Westminster, London, S.W.1, General Meeting, in Conjunction with the Industrial Administration and Engineering Production Group, "The Economics of Plant Replacement and Renewals," C. W. Griffiths, 6 p.m.——SCOTTISH BRANCH: Robert Gordon's College, Aberdeen, "The Salvaging of Ships, with particular reference to the 'Empress of Canada,'" W. R. Colbeck, 7.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Wed., Feb. 6.—JOINT MEETING WITH THE INSTITUTE OF MARINE ENGINEERS: Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, Symposium "The Education and Training of Naval Architects and Marine Engineers," 10 a.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Feb. 5.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Engineering Stores—Estimating and Supplies," C. J. Cameron, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Feb. 4.—N.W. REGION: College of Technology, Sackville Street, Manchester, "The Design, Manufacture and Use of Sin Sliding, Surfacing and Screwcutting Lathes," D. H. Turnbull, 7.15 p.m.

Tues., Feb. 5.—S.E. REGION: Old Ship Hotel, Brighton, "Some Aspects of Automation," A. L. Stuchbery, 7 p.m.——EAST AND WEST RIDINGS REGION: George Hotel, Huddersfield, "Training of Production Managers and Engineers," G. S. Bosworth, 7.15 p.m.

Wed., Feb. 6.—S.E. REGION: Ilford Club, 21a, Balfour Road Ilford, "Optics as an Aid to the Engineer," John R. Adams, 7.30 p.m.——MIDLANDS REGION: Craven Arms, High Street, Coventry, "The Technique of Introducing a New Materials Handling Method," L. J. Hoefkens, 7.15 p.m.——Technical College, Dudley, "Making Jigs, Tools and Moulds in Epoxide Plastics," P. G. Pentz, 7.15 p.m.——N. MIDLANDS REGION: Victoria Station Hotel, Milton Street, Nottingham, "Tool Grinding," R. J. Cowie and J. K. Church, 7 p.m.

Thurs., Feb. 7.—SOUTHERN REGION: Great Western Hotel, Reading, "Some Aspects of Jig and Fixture Design," K. V. Trotter, 7.30 p.m.

Fri., Feb. 8.—EASTERN REGION: Diocesan Hall, Tower Street, Ipswich, "Production Methods in Large Scale Engineering Jobbing Work," J. F. Rice, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 4.—N.E. SECTION: Eldon Grill, Grey Street, Newcastle, "Some Aspects of Rubber Processing," B. L. Davies, 7 p.m.

Tues., Feb. 5.—LONDON SECTION SALES MEETING: Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, "Publicity for Technical Products," G. C. Graver, 6.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Feb. 1.—MIDLAND COUNTIES GRADUATES AND STUDENTS' SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Erection Procedure with special reference to Erectors' Problems," A. G. Osborne, 6.30 p.m.

Tues., Feb. 5.—NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough, "Joints in Steel Rigid Frameworks," G. Bernard Godfrey, 6.30 p.m.——NORTHERN IRELAND BRANCH: College of Technology, Belfast, "Practical Applications of Soil Mechanics," 6.30 p.m.

Wed., Feb. 6.—MIDLAND COUNTIES BRANCH: Wolverhampton and Staffordshire Technical College, Wolverhampton, "The Application of Welding to Structural Steelwork," J. S. Allen, 7 p.m.——NORTHERN COUNTIES BRANCH: Neville Hall, Newcastle, "Joints in Steel Rigid Frameworks," G. Bernard Godfrey, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 1.—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Trans-Ocean Deep-Sea Submerged Repeater Systems," E. F. S. Clarke, 7 p.m.

Fri., Feb. 8.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Kinematic Design," R. J. Herbert, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Feb. 8.—Engineers' Club, Albert Square, Manchester, 2, "The Post-War Trend of Power Station Plant Design," F. J. Hutchinson, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Feb. 8.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "The Development of Refractory Nozzle Blades for Use in High Temperature Gas Turbines," T. H. Blakeley and R. F. Darling, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Feb. 5.—N.W. BRANCH: College of Technology, Sackville Street, Manchester, "Load Factor Design of Reinforced Concrete Buildings," D. D. Matthews, 6.45 p.m.——MIDLAND COUNTIES BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "Reinforced Concrete in Architecture," Edward D. Mills, 6 p.m.

Wed., Feb. 6.—N.W. BRANCH: Liverpool Engineering Society, The Temple, 24, Dale Street, Liverpool, "Load Factor Design of Reinforced Concrete Buildings," D. D. Matthews, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Feb. 7.—MAIN LECTURE AT HALTON BRANCH: The Canteen, Air Trainers, Ltd., Aylesbury, Bucks, "Synthetic Training Methods in Aviation," W. Makinson, 6.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., Feb. 6.—John Adam Street, London, W.C.2, Cadman Memorial Lecture, "Mining Education and Training," I. C. F. Statham, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Tues., Feb. 5.—MERSEYSIDE GROUP: Royal Institution, Colquitt Street, Liverpool, 1, "The Latest Developments in Quality Control in the U.S.A.," C. S. Smith, 7 p.m.

Wed., Feb. 6.—BIRMINGHAM GROUP: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Statistical Bases of a Study of the Effects of Television," W. A. Belson, 6.45 p.m.

SOCIETY OF ENGINEERS

Mon., Feb. 4.—INAUGURAL MEETING: Geological Society, Burlington House, London, W.1, Presidential Address, E. C. Lejeune, 5.30 p.m.

UNIVERSITY OF LONDON, KING'S COLLEGE

Mon., Feb. 4.—PUBLIC LECTURE: King's College, Strand, London, W.C.2, "The Undergraduate and Post-Graduate Education of Engineers in European Countries," S. J. Davies, 5.30 p.m.